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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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See Advertisement last week, page 91.

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Specification and Workmanship equal to Main Line Locomotives.
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See Advertisement page 77, Oct. 13.

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818

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PRESSURE, AIR, STEAM
For Boilers of all types.
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Naval Outfits a Speciality,
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designed and constructed by
MANNING, WARDLE AND COMPANY, LIMITED,
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See their Illus. Advertisement, page 96, last week.
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and
INDUSTRIAL PROPERTIES. 9686
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Birkenhead.
See Illustrated Advertisement Page 97, Oct. 13.

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Steam and Electric Cranes
EXCAVATORS, CRANE-NAVVIES, GRABS,
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DECK MACHINERY. 627
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See Advertisement Page 84. 9663

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HIGH BOILER EFFICIENCIES
ARE OBTAINED BY INSTALLING
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FUEL OIL BURNING SYSTEMS,
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Builders of Steam and Motor Ships, Repairers, Electric Drive Installations.
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The Glasgow Railway Engineering Company,
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The Strongest Chain 868
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Makers of WHEELS and AXLES, RAILWAY PLANT, FORGINGS, SMITH WORK, IRON & BRASS CASTINGS, PRESSED STEEL WORK OF ALL KINDS.
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Two and Four stroke, 850, 1000, 1200 H.P., excellent condition. Dynamos for above 200 or 500 volts, D.C. Immediate delivery and low price
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819

Matthew Paul & Co., Ltd.
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See Full Page Advt., page 60, Oct. 13.

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For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER.
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See half page advert., page 20, Oct. 13. 8195

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&c. &c. 846

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Centrifugals.
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MOTHERWELL, SCOTLAND. 939
See half-page Advertisement page 97, Sept. 29.

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For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.
Chief Engineer: G. E. Stromeyer, M.I.C.E.
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Inst. C.E. Exams.—Successes as usual last Exam. by Correspondence Coaching. Successes by hundreds, several prizes. Sec. "O" embraces 25 years' professional experience.—Address, 7434, Offices of Engineering.

Powering of Vessels.—A Practical Course of Instruction by Correspondence.—Address, for particulars and terms, 148, Offices of Engineering.

A Brochure on "Engineering Salesmanship and Sales Management," written for engineers, by an ENGINEER SALES MANAGER, will be sent post free on application to DIRECTOR, The Institute of Engineering Salesmanship, 333, Oxford Rd., Manchester. 985

TENDERS.

SELBY URBAN DISTRICT COUNCIL.

The Above named Council invite

Tenders for the Erection of a Girder or Ferro-Concrete Bridge.

Plans and Specifications to be sent in by Contractors.

The Council do not bind themselves to accept the lowest or any Tender or Design.

Particulars may be obtained at my Office.

BRUCE GRAY, A.M.I.C.E., F.R.S. Edin., Council Offices, Selby. W 498

THE HIGH COMMISSIONER FOR INDIA is prepared to receive

Tenders for the Supply of:—

92 LOCOMOTIVE ENGINES AND TENDERS.

Tenders are being invited simultaneously in India and in England.

Forms of Tender may be obtained from the Director-General, India Store Department, Branch No. 16, Belvedere Road, Lambeth, S.E. 1, and Tenders are to be delivered at that Office not later than Two o'clock p.m. on Tuesday, the 16th January, 1923.

T. RYAN, Director-General. W 554

THE HIGH COMMISSIONER FOR INDIA is prepared to receive

Tenders for the Supply of:—

1. TYRES, STEEL, for railway carriage and wagon wheels.
2. SPRINGS, laminated, bearing and buffing, for locomotive engines, etc.
3. AXLE BOXES, engine, cast steel.
4. WHEELS AND AXLES.
5. STEEL, mild, hexagon bars.
6. BRASS AND COPPER, bolt or rod.

Forms of Tender may be obtained from the Director-General, India Store Department, Branch No. 16, Belvedere Road, Lambeth, S.E. 1, and Tenders are to be delivered at that Office not later than Two o'clock p.m. on Tuesday, the 7th November, 1922, for No. 1; on Thursday, the 9th November, 1922, for No. 2, and on Friday, the 10th November, 1922, for Nos. 3 to 6.

T. RYAN, Director-General. W 558

STATE ELECTRICITY COMMISSION OF VICTORIA.

TENDERS FOR PLANT.

Tenders are Hereby Invited for the SUPPLY, DELIVERY, etc., of the following for the Morwell Power Scheme.

Copies of Tender Form and Specification may be obtained or inspected upon application to:—

AGENT-GENERAL FOR VICTORIA, Melbourne Place, Strand, London, W.C. 2.

Specification No. 33/4—STEAM TURBINE-DRIVEN BOILER FEED PUMPS.

Charge:—£1 1s. for the first two copies of Tender Form, Conditions of Contract, and Specification complete. These charges will be returned on receipt of a *bona fide* Tender. A third and any further copies will be supplied for the sum of 10s. 6d. each.

Preliminary Deposit:—A Preliminary Deposit of £24 is required to be lodged with Tender.

The Commission does not bind itself to accept the lowest or any Tender.

Tenders on prescribed form, properly endorsed and addressed, must be delivered to the undersigned in Melbourne not later than Five p.m. on 19th January, 1923.

R. LIDDELOW, Secretary.

State Electricity Commission of Victoria, Melbourne, Victoria, Australia. W 559

HOPPER BARGE.

THE TRUSTEES OF SHOREHAM HARBOUR invite

Tenders for the Supply and DELIVERY of a suitable HOPPER BARGE capable of carrying about 200 tons of dredged material. Full particulars as to age, condition and price to be sent to the undersigned on or before Saturday, 4th November, next.

The Trustees do not bind themselves to accept the lowest or any Tender.

CRANFIELD BAGULEY, Clerk to the Trustees.

Harbour Offices, Southwick, Brighton, 17th Oct., 1922. W 587

THE METROPOLITAN ASYLUMS BOARD invite

Tenders for Docking and UNDOCKING the AMBULANCE STEAMER "RED CROSS" in accordance with specification prepared by Mr. Thomas Cooper, M.I.C.E., Engineer-in-Chief to the Board.

Specification, Conditions of Contract and Form of Tender may be obtained at the Office of the Board, Embankment, E.C. 4.

Tenders addressed as noted on the form, must be delivered at the office of the Board not later than Ten a.m. on Saturday, 4th November, 1922.

G. A. POWELL, Acting Clerk to the Board. W 590

THE BURMA RAILWAYS COMPANY, LIMITED.

The Board of Directors of the Burma Railways Company, Limited, are prepared to receive

Tenders for the Supply of:—

89 tons RED AND WHITE LEAD—
Red Lead, dry, 40 tons;
White Lead, dry, 4 tons; and
White Lead ground in oil, 45 tons.

For each copy of the Specification a fee of 10/- will be charged, which fee is not returnable. Tenders enclosed in sealed envelopes endorsed "Tender for Red and White Lead" must be delivered at the Company's Offices not later than 12 noon on Tuesday, 31st October, 1922.

The Directors do not bind themselves to accept any or the lowest tender, and reserve the right to divide the order.

Part of the work is urgently required in Burma.

By order of the Board, F. C. FRANKS, Secretary.

190, Gresham House, Old Broad Street, London, E.C. 2.

19th October, 1922. W 602

EDINBURGH CORPORATION ELECTRICITY DEPARTMENT.

Applications are Invited for the following POSITIONS in the Electricity Department of the Corporation:—

(a) COST CLERK with sound knowledge of Book-keeping and modern costing methods, as used in large Industrial Works. Must be strict disciplinarian. Present Salary and bonus £266 per annum.

(b) Energetic and Experienced CLERK to assist in secretarial work; must possess a knowledge of shorthand and typewriting and modern filing methods. Present salary and bonus £215 per annum.

Applicants for both appointments must have sound educational qualifications and none but thoroughly experienced men need apply. Applications stating age, giving full particulars of previous experience, accompanied by copies of three testimonials, must be sent to the undersigned by October 28th, 1922.

FRANK A. NEWINGTON, Engineer and Manager.

Electricity Supply Offices, Dewar Place, Edinburgh. W 585

BOMBAY, BARODA & CENTRAL INDIA RAILWAY COMPANY.

The Directors are prepared to receive up to Noon on Wednesday, 8th November.

Tenders for the Supply of:

1. OVERBRIDGE.
2. STEEL MATERIAL for Construction of Wagons, etc.
3. WHEELS & AXLES.

Tenders must be made on forms, copies of which, with specification, can be obtained at these offices on payment of 20/- each for Nos. 1 and 2, and 10/- each for No. 3 (which will not be returned).

The Directors do not bind themselves to accept the lowest or any Tender.

S. G. S. YOUNG, Secretary.

Offices: The White Mansion, 91, Petty France, Westminster, S.W. 1. 17th October, 1922. W 573

COUNTY OF LONDON.

ISLE OF DOGS PUMPING STATION ENLARGEMENT.

The London County Council invites

Tenders for the Construction of an ENGINE HOUSE in brick and concrete with slate roof, internal dimensions 76 ft. by 48 ft. by 33 ft. high to the eaves, partly above and partly below ground, and foundations for engines, pumps and auxiliary Machinery; also the Construction of Supply, Suction and Delivery Culverts, and a Penstock Chamber and other subsidiary works. The work will be situated in the metropolitan borough of Poplar.

The Specification, Form of Tender, etc., may be obtained on and after Monday, 23rd October, on application to the Chief Engineer of the Council at the Old County Hall, Spring-gardens, S.W. 1, upon payment of the sum of £5. This amount will be returnable only if the tenderer shall have sent in a *bona fide* Tender and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application, and the contract documents may be inspected before the payment of the fee.

No Tender received after Four p.m. on Monday, 30th November, 1922, will be considered. The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD, Clerk of the London County Council. W 589

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED, are prepared to receive

Tenders for the Supply of:—

1. MILD STEEL BARS, SECTIONS, etc.
2. YORKSHIRE IRON.
3. WROUGHT IRON.
4. SPRING STEEL.
5. BOLTS, NUTS AND RIVETS.
6. HEMP AND COTTON FABRICS, etc.
7. CARRIAGE UNDERFRAMES.

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W. 1.

Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tender for Mild Steel Bars, Sections, etc.," or as the case may be, must be left with the undersigned not later than Twelve Noon on Friday, the 3rd November, 1922, in respect of Nos. 1 to 6, and not later than Twelve Noon on Friday the 17th November, 1922, in respect of No. 7.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 10s. for each copy of Specifications Nos. 1 to 6, and of £1 for each copy of Specification No. 7.

Copies of the Drawings may be obtained at the Office of Messrs. Robert White & Partners, Consulting Engineers to the Company, 3, Victoria Street, Westminster, S.W. 1.

A. MUIRHEAD, Managing Director.

91, Petty France, S.W. 1. 19th October, 1922. W 606

APPOINTMENTS OPEN.

UNIVERSITY OF DURHAM.

ARMSTRONG COLLEGE, NEWCASTLE-UPON-TYNE.

LECTURER IN ELECTRICAL ENGINEERING.

Applications are Invited for the above Post. Salary £300 per annum. Appointment for one year, which may be extended. Duties to commence as soon as possible.

Last date for application, 30th October.

Further particulars may be had on application to the REGISTRAR, Armstrong College. W 561

Wanted, First-class Foreman MANAGER for Works manufacturing all kinds of Ventilating Duct work; also all kinds of Hoppers, Elevators, Chutes, etc., in plate ranging from 24 gauge to ¼ in.; must be fully acquainted with all developments and capable of fixing piece-work rates. No application considered unless giving full particulars of experience, salary, etc.—Address, W 597, Offices of Engineering.

Required, Assistant to the Manager of the branch office in Calcutta of an Engineering firm. Applicants should be 25 to 35 years of age and preferably unmarried. They should be Associate Members of the Inst. C.E., or hold equivalent qualifications. They should be of good social standing and presence and Engineers with mechanical training and waterworks experience will be given preference. The Engineer appointed will be required to undergo a short period of training in the firm's English Office; the appointment will be subject to two months probation and will be thereafter for one year certain, extended to permanent employment to an Engineer who has proved himself in every way suitable. The inclusive salary offered is £400 per annum with free first-class passage out and home but a higher salary will be offered to an applicant who is specially suitable. Full particulars of training, experience, etc., accompanied by copies of recent testimonials should be forwarded.—Address, W 582, Offices of Engineering.

Representative Engineer- TRAVELLER REQUIRED by well-known British Manufacturers of Industrial Dynamos and Motors—for London and surrounding district up to 50 miles radius. State, in confidence, full particulars as to previous locality worked, experience, training, age, and salary expected.—Address, W 567, Offices of Engineering.

Wanted Immediately for a London College, JUNIOR ASSISTANT to undertake supervision of machine drawing and geometrical drawing classes, also 1st year classes in Mechanical Laboratory. Candidate must have had some drawing office experience and be a competent mechanical draughtsman, and have good technical or scientific qualifications. Salary £150 p.a.—Write, ENGINEER, c/o Charles Barker & Sons, Ltd., 31, Budge Row, E.C. 4 W 607

Engineer.—A Firm of Con- sulting Engineers REQUIRE FIRST-CLASS ENGINEER to represent them in India. Must have good Electrical and Railway engineering experience. State age and salary required and when available.—Address, W 601, Offices of Engineering.

Engineer Wanted for India, for post of Assistant Superintending Engineer. Five years' agreement. Rs. 630 per month to Rs. 850 by yearly increments of Rs. 50 per month. Free quarters provided or allowance for quarters given. Free passage. Marine engineering experience, works and drawing office, and technical education essential.—State age, and whether single or married, to D. M., c/o Pottle & Sons, 15, Cullum Street, London, E.C. 3. W 561

Consulting Engineers Require a SENIOR ASSISTANT ENGINEER for preparation of reports and estimates principally in connection with railway electrification; good theoretical training and some practical experience essential. Remuneration about £700 per annum depending on qualifications.—Apply, stating age and experience, to W 576, Offices of Engineering.

Wanted for Spain, to Organize and Develop a Spanish Branch of a well-known English Company. Fluent Spanish essential. Some knowledge of Electrical Machinery desirable. Age 30 to 35.—Address, W 552, Offices of Engineering.

MINING SCHOOL, PORTSMOUTH.

A Vacancy Exists for an ENGINEER TO TAKE CHARGE OF DESIGN.

Salary £300, rising by annual increments of £15 to £500, and full Civil Service Bonus.

Commencing Salary, including bonus at present payable, £449 12s. 6d.

The bonus is subject to an increase or decrease based on cost of living.

The post will carry Superannuation benefits under the Federated Universities Superannuation Scheme.

Good technical qualifications are required, a degree or diploma in Engineering being desirable. Experience in Engineering Design for Automobile or similar work is essential. A general knowledge of Engineering Shop practice and production methods will be taken into consideration.

Applications should be made to the SECRETARY, Admiralty (C.B. Branch), London, S.W. 1. W 559

Chief Engineer Required by the Posts and Telegraphs Department of the SUDAN GOVERNMENT.

Candidates should not be less than 35 years or more than 40, preferably unmarried and must have intimate knowledge and practical experience of Telegraph, Telephone and Wireless details as will enable them to undertake the management of 70 Telegraph Offices, 4000 miles of pole line, Telephone Systems at Khartoum, Khartoum North, Omdurman, and at various out stations, the Wireless system at 13 stations and the installation of new stations, the Telegraph Clearing House, and the management of the staff at the various stations. A slight knowledge of administrative duties will be very valuable. Permanency if found satisfactory after two years probationary period. Strict medical examination. Free passage out to the Sudan. One period of leave during the probationary period subject to the exigencies of the service. Salary—£852 per annum plus a war bonus in accordance with the rules for the time being in force as long as war bonus is being paid. The present bonus is £384 per annum (£81 = £1 0s. 6d.).—Applications for further details of qualifications, duties and conditions of service should be made to The INSPECTING ENGINEER, Egyptian & Sudan Governments, Queen Anne's Chambers, Westminster, S.W. 1. Envelopes to be marked "CHIEF ENGINEER." W 604

Bridge Works Foreman REQUIRED for Chinese Government Railways; experience in Plate and Lattice Girder construction, and general structural work essential. Two years' agreement with salary of £360 and £372 per annum, including free quarters.—Write stating qualifications and past experience, age, physical fitness, etc., to "N.W.," c/o J. W. Vickers & Co. Ltd., 5, Nicholas Lane, E.C. 4. W 608

Designer, Experienced in Alternating Current Motors for High-class dynamo and motor manufacturer. State experience, age and salary.—Address, W 593, Offices of Engineering.

Draughtsman Wanted, with sound mechanical training, for Works in Midlands. Some Electrical and building construction knowledge desirable.—Address, giving particulars of experience, age, and wages required, to W 551, Offices of Engineering.

First-class Draughtsman WANTED, experienced in designing and detailing all classes of Steam and Electric Cranes.—Apply, by letter, stating age, experience, and salary, to THOMAS SMITH & SONS (Rodley), Ltd., Steam and Electric Crane Works, Rodley, near Leeds. W 489

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Manager, Representative or CONSULTANT, Home or abroad.—Engineer with Marine Training and comprehensive general engineering and commercial experience as manager Docks, Armament Works, and Engineering factory, and as Commercial Representative DESIRES POST. Is capable taking independent charge, after provision of Capital to successful and profitable Running of any sound Engineering Proposition, knows men, matters and languages, various Countries, age 36. M.I.N.A., first-class references. Has own office, London, and can retain same if necessary.—Address in confidence, W 512, Offices of Engineering.

Dredging Superintendent Requires Position. First-class experience, including office management, costs, etc.; repairs and maintenance of plant. Good references.—Address, W 544, Offices of Engineering.

Government Official, India; age 45 British; desires to return to England and SEEKS APPOINTMENT as Consulting Engineer, Chief Engineer or Chief Inspector to Insurance Concern (Marine, Machinery, Boiler, Fire, etc.).—Address, W 263, Offices of Engineering.

Advertiser, A.M.I.Mech.E., A.M.I.E.E., 13 years' experience in India, Practical and Commercial, Desires Responsible Post, Home or Abroad. Address, W 579, Offices of Engineering.

LITERATURE.

Activities of the Bureau of Yards and Docks, Navy Department. World War, 1917–18. Washington: Government Printing Office, 1921.

Among the host of intensive activities called into being or developed to meet the unprecedented demands of the naval and military authorities for the prosecution of the world war there is none perhaps which is of deeper interest than the phenomenal development of the naval resources of the Allied Powers, and particularly of Great Britain and America. That the pre-war organisations for the control of the naval services and requirements were quite inadequate to cope with the demands arising from the world war is, of course, obvious, and the methods whereby the necessary development was made to meet the unprecedented demands are therefore of very considerable interest. The publication of the official record of the Activities of the Bureau of Yards and Docks for the period covered by the participation of America in the war is interesting not only as a record of work accomplished, but also as a record of the development of the Bureau from 1911 till 1918, during which time its activities increased enormously, as is shown by the fact that during the period 1914–1918 the value of the public works of the Navy increased in value from 211,000,000 dols. to 469,000,000 dols.

Prior to July, 1916, the Bureau consisted of one Chief of Bureau, a chief clerk, a small number of engineers of the Navy and a civilian *personnel* of 59 men and 4 women. In November, 1918, the *personnel*, exclusive of officers, numbered 714. The general scheme of the Bureau was in its essential features very similar to the modern works management organisation where departmental managers take charge under the works manager and general manager, but the scope of the Bureau's activities was such that the number of departmental managers, or, as they were called, project managers reached the number of 10. The sections were as follows:—Dry docks; armour and projectile plant; Naval Academy; magazines and general ordnance facilities; aviation and submarine bases; shipbuilding and yard development projects; marine corps, fuel oil, radio, and routine projects; hospitals; power plants and training camps. Each section was under the charge of a project manager, and each project manager was provided with a civilian assistant and the necessary number of draughtsmen, &c., for the work of his section. Project managers were responsible to the Assistant Chief of Bureau, and through him to the Chief of Bureau. The system certainly amply justified itself during the period of maximum pressure not only in regard to the amount of work dealt with but also by reason of the varied nature of the problems handled.

In the matter of Naval training camps alone, some idea of the magnitude of the tasks overtaken may be got from the fact that whereas at the outbreak of war in 1917, there were available four training stations with accommodation for a total of 6,000 men, at the signing of the armistice these numbers had been increased to 40 stations with accommodation for 191,000 men in winter and 205,000 men in summer. Much of this accommodation was provided by taking over existing buildings, and by the erection of timber houses of a more or less temporary nature, but all furnishings and equipment, roads, water services, heating and lighting plant, &c., were arranged by, and carried out under, the supervision of the Bureau.

Of Marine Corps projects the most important was the design and construction of an expeditionary base at San Diego, California, comprising barracks for 1,700 marines, quartermaster's storehouse, expeditionary storehouse, electric lighting, heating and refrigerating systems, &c., and involving the construction of a sea wall, shipping pier, &c. Many other training barracks, store houses, &c., were designed and carried through by the Bureau for the Marine Corps. Emergency hospital construction involved the erection and furnishing of about 500 large hospital buildings providing for a patient and attendant *personnel* of 17,000 in the United States and 13 overseas hospital stations.

Facilities for the construction of naval vessels of all classes, both as regards actual building slips and as regards general facilities for rapid construction, received very close attention from, and were very considerably extended under, the control of the Bureau, and it is worthy of note that where new building slips were made or old ones extended these were designed and constructed for capital ships of 1,000 ft. long, 109 ft. beam and of 45 ft. draft. This should ensure an ample margin for such development in dimensions as may be expected for a considerable period. In all some 21 new slips were built for naval vessels, with the necessary overhead and other crane facilities, while fitting out piers and the appropriate new shops, stores, &c., required in connection with the extended building facilities were provided. As typifying the scale upon which the new facilities were designed the case of the crane installed at the Philadelphia yard may be cited. This crane has a lifting capacity of 350 tons, and is designed to lift and place on board large items such as turrets, &c., which may be built up complete in the shops and transported alongside the vessel either by rail or floated round in a barge. In this way much time lost in dismantling and re-erecting will be saved, and the fitting out time of a capital ship considerably reduced.

In addition to the large extensions of facilities in the naval yards the plant of some 46 private firms was extended for war purposes under the direction and superintendence of the Bureau, and of these plants 34 were engaged in the building of destroyers, submarine, minesweepers, submarine chasers, and accessories for these vessels. The total outlay on these extensions amounted to more than 71,000,000 dols, and they were for the most part financed by the Government. It is calculated that the net cost to the Government, after allowing for sales of plant extensions to the private firms and other realisable assets, will be about 41,000,000 dols., and this is reckoned at less than 6 per cent. of the cost of the additional fleet units of which the construction was made possible or very materially hastened by the above expenditure. In the matter of dry docks the United States Navy has during the war period or shortly thereafter obtained either by construction, purchase or preferential rental the use of five dry docks of the largest size, three on the Atlantic and two on the Pacific coasts, while two dry docks of 471 ft. long have also been constructed.

Under the heading of "Power Plants" the Bureau records the enormous number of projects designed and executed in extending existing shipyard and other works plants to meet the greatly increased emergency production required, also the design and construction of new power, lighting, heating, &c. plants, required for new factories, training camps &c. While there is nothing of special engineering interest recorded in this section the mere statement of the projects put through compels admiration of the technical and constructive skill shown in accomplishing so much in such a short time.

In common with all other naval requirements the facilities for the manufacture, assembling and storing of guns, torpedoes, mines and ammunition proved totally inadequate to meet the war-time requirements, and here again additions and extensions were carried out to bring facilities into line with the new requirements. In this connection special interest attaches to the large armour, gun and projectile plant designed and constructed at Charleston, W. Va. for the United States Government. The plant is capable of turning out armour plates and guns of the largest sizes, and is equipped in the most thorough and up-to-date manner. Designed to remedy the deficiency in output from the existing privately-owned plants capable of handling the largest sizes of guns and armour the new plant will continue to be operated by the Government as a check on prices and as a supplementary and experimental plant.

Storage facilities for new shipyards, fleet supply bases, coaling depots, and oil fuel storage, involving the construction of a large number of storehouses, tanks and reservoirs, several of the latter at points abroad, formed yet another of the activities of the Bureau of yards and docks. Of storehouses alone about 30 large permanent buildings and over 100 temporary buildings have been erected since 1916, providing in all 15,000,000 sq. ft. of storage area, while additional temporary accommodation on a considerable scale was provided by renting existing buildings and by using army supply bases.

Submarine and aviation bases both in America and abroad entailed a considerable amount of labour and arrangement but involved no new departure of interest. The production of helium from natural gas and its use as a substitute for hydrogen as a buoyant agent in lighter-than-air craft, originated by British scientists, was successfully carried out in America at a special plant erected for the purpose at Fort North, Texas, and for the design and construction of which the Bureau were partly responsible. The capacity of this plant is 40,000 cub. ft. of helium per day and the cost of the plant about 3,500,000 dols. As a record of the wartime activities of the Bureau of Yards and Docks the report under notice leaves little to be desired, the various projects and activities being described and illustrated in considerable detail, while the scope and magnitude of the activities dealt with indicate most clearly the thoroughness with which America, having made up her mind to join the Allies, tackled the enormous difficulties of an unprecedented situation.

The Czecho-Slovak Republic; A Survey of its History and Geography; its Political and Cultural Organisation and its Economic Resources. By Jaroslov Čisar and F. Pokorny. London: T. Fisher Unwin Limited. Prague: Orbis Publishing Company. [Price 9s. net.]

To many the term Czecho-Slovakia is but a geographical expression. They would have a difficulty in defining its position on the map of Europe, its achievement in past history, its industrial opportunities, or its legitimate ambitions. The authors, in conjunction with several collaborators, have designed this volume, which they modestly style a compilation, to remove the prevalent uncertainty, by furnishing exact and detailed information concerning the new Central Republic, which has emerged from the European debacle, and whose friends hope may justify its existence by exhibiting political stability and economic development. The work aims at giving prominent facts, and does not attempt any deep research into ancient records or original sources of information. The work of the critical historian must come later to whose more adequate work the present contribution may be regarded as an index.

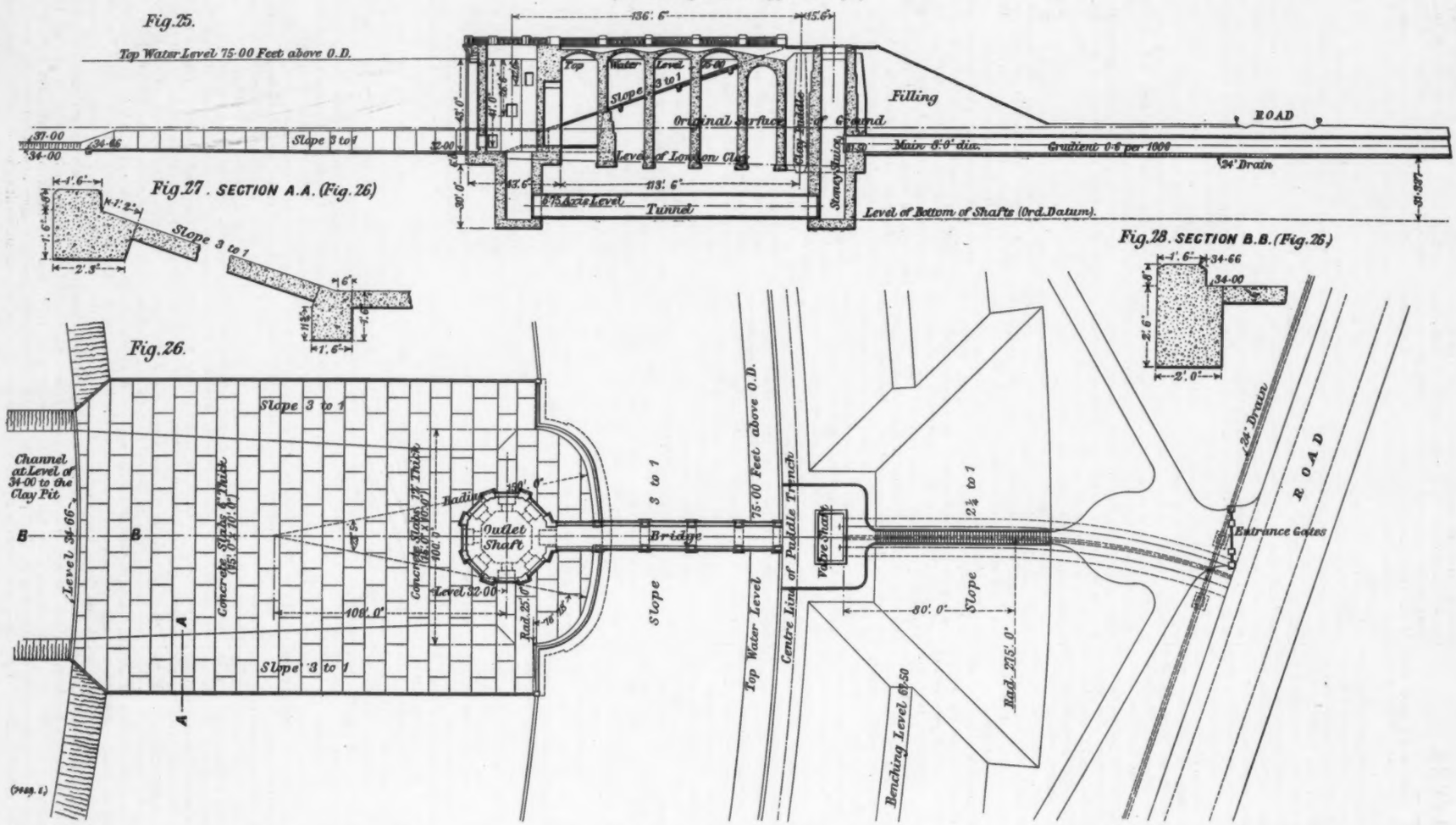
The book is divided into two parts. The first outlining the history, geography, and political organisation of the Republic, the second describing the natural resources of the country and the prospects of industrial revival. The historical sketch is mainly supplied by President Masaryk, who assures us that the policy of the new State will be directed to the maintenance of peace with its neighbours and the preservation of existing treaties, as the only possible basis for the reconstruction of Central Europe. Mr. Paul Selver contributes a chapter on Czech Literature, and Mrs. Rosa Newmarch writes on national music, both authors looking hopefully to the future rivalling the past when education and the fine arts flourished.

The second half of the book will probably attract the greater share of attention, because material progress and national development are at the present moment of more importance than the cultivation of the fine arts, which cannot advance till settled social conditions follow on the re-establishment of production on a normal basis. Naturally the authors take a hopeful view of the future, and the statistics they are able to produce apparently warrant their confidence, but the fluctuations of exchange make any deductions uncertain. Coal and iron, agricultural products and other natural wealth are, however, independent of the paper currency, and the abundance of these points to a prosperous future, if political ambitions permit and labour and industry determine to exploit this opulence to the utmost. Transportation seems to offer difficulties and may eventually cause unrest. Most of the products known on the world market as Austrian are of Czech origin, and can, and will be manufactured in the Republic, but the country does not possess the outlets to the sea and the facilities for exportation that Austria enjoyed. To an industrial country importing chiefly raw materials and exporting finished manufactured goods the control of commercial routes and easy communication is of prime importance. It is

OUTLET WORKS OF THE LITTLETON RESERVOIR OF THE METROPOLITAN WATER BOARD.

MR. H. E. STILGOE, M.INST.C.E., CHIEF ENGINEER TO THE METROPOLITAN WATER BOARD, ENGINEER.

(For Description, see opposite Page.)



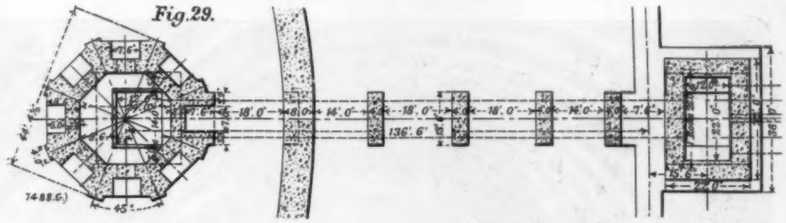
urged that the Elbe will give access to Germany and the Danube to South East Europe, while the Oder will afford an outlet to Poland. These routes seem to place a limit on the extent of trade rather than to encourage it. These waterways may be sufficient for the present restricted output, but with the increase anticipated on the expiration of the present paralysing jealousies and strife, the necessity for greater freedom may make itself acutely felt. The stragetic position for trade on which the authors congratulate the country may hardly prove the asset they imagine.

Looking at the well-arranged statistical tables, these days of revitalised commerce may come more quickly than anticipated. For of all the nations and groups called into being by the Treaty of Versailles, on the plea of "self-determination" and the right to nationality, none has made as good a claim to be considered as a separate entity, or exhibited the same capacity for Government, as the Republic of Czecho-Slovakia. Surrounded by nations sunk in bankruptcy and consumed by pernicious revolutionary doctrines, this new Republic has determined to work out its own salvation, notwithstanding that the country is compelled to bear some portion of the loss and burden entailed by the downfall of the House of Hapsburg. Struggling against evil example and corrupt practices, the country has refused to have recourse to the printing press, which points a facile road to economic ruin. The authors can say proudly that in the budget of 1921, revenue and expenditure balance, and even show a small surplus on the right side. There are, too, encouraging signs in other statistical tables drawn from official sources, giving the output of coal and minerals, the value of agricultural produce, the extent of the iron and steel industries, the manufacture of porcelain, and the progress made in the textile products. Some of these industries have been hampered by the destruction of railways and

OUTLET WORKS OF THE LITTLETON RESERVOIR.

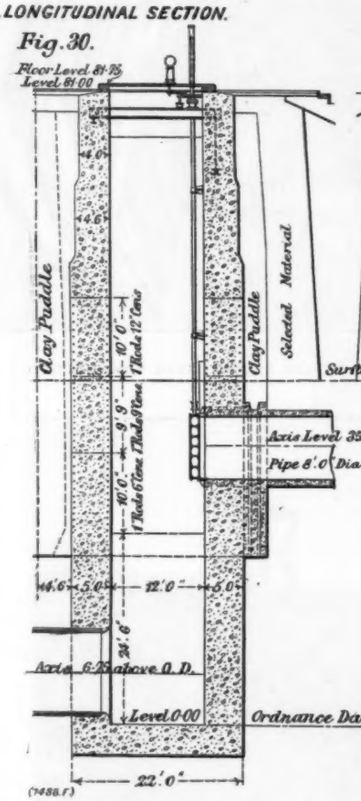
MR. H. E. STILGOE, M.INST.C.E., ENGINEER.

Fig. 29.



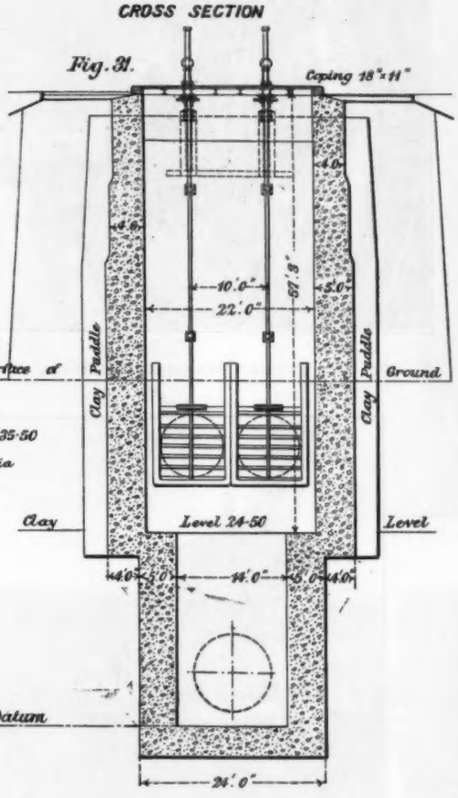
LONGITUDINAL SECTION.

Fig. 30.



CROSS SECTION

Fig. 31.



LONGITUDINAL SECTION

Fig. 32.

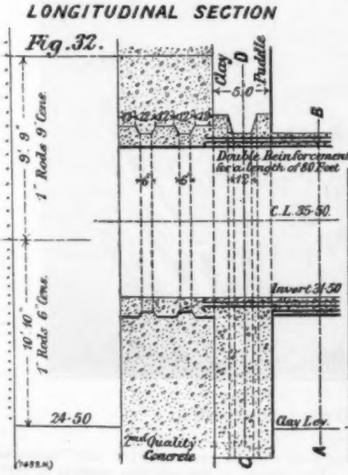


Fig. 33. SECTION C.D.

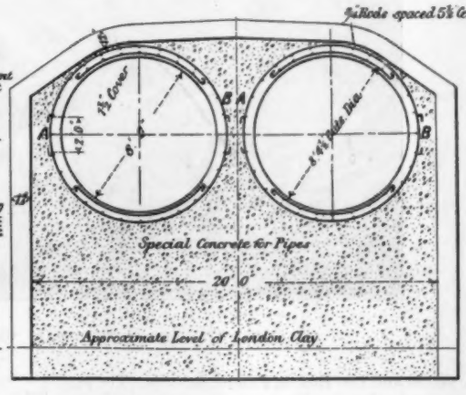


Fig. 34. SINGLE REINFORCEMENT

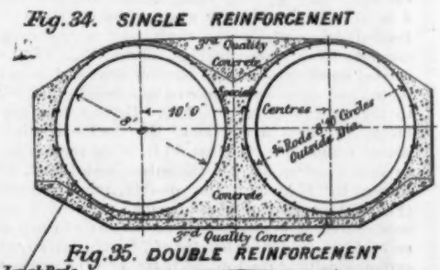
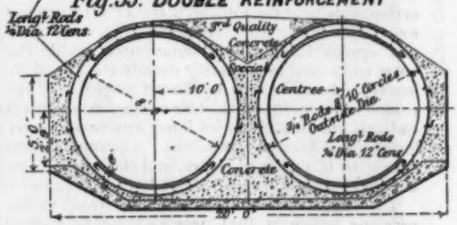


Fig. 35. DOUBLE REINFORCEMENT



rolling-stock during the war, the working of mines with undue haste under war pressure, the difficulty of procuring fertilisers, the general want and high prices of raw materials, and other causes that can easily be imagined as the consequences of the upheaval through which the country has passed. But each year declares an improvement on the preceding, and it is this indication of increasing stability which gives rise to the conviction that Czecho-Slovakia must be regarded as a permanent institution, and not as an ephemeral and artificial creation, liable to be swallowed up by more powerful neighbours or overwhelmed in the whirlwind of an aggressive Bolshevism.

The facts which the authors have so well put before us deserve to be widely known. They are an encouragement to the cause of good government, and help us to understand how much has been achieved in the face of impending disaster. All who have at heart the cause of honest and sober progress will congratulate the authors on the report they are able to submit.

THE LITTLETON RESERVOIR FOR THE METROPOLITAN WATER BOARD.

(*Concluded from page* 419.)

THE outlet works of the Littleton Reservoir are illustrated in Figs. 25 to 41 on the present and opposite pages, and pages 482 and 483. This is the most advanced portion of the undertaking at present. The outlet will be seen from Fig. 2, page 417 *ante*, to be situated at the corner of the reservoir near Ashford Common. Elevation and plan of the outlet are given in Figs. 25 and 26, page 480, while the two views Figs. 38 and 39, on page 483, give a good idea of the general appearance inside the embankment. The outlet consists of two valve shafts connected at low level by a tunnel, and the top of the inner tower connected with the embankment by a five-arched bridge which is to be seen in Figs. 38 and 39. The inner valve shaft is also shown in these views. The outer shaft is built into the embankment, as shown in Figs. 25 and 26, page 480, just outside the puddle core.

From the interior of the reservoir the outlet is approached by a channel 100 ft. wide cut to a level of 34·0 O.D., the normal bottom level at this side being 37·0 O.D. This terminates in a lined forebay with sloping sides, in which the inner valve shaft is situated. The floor of the forebay slopes towards the valve tower, where its level is 32·0 O.D. It tapers from 100 ft. wide to 80 ft. wide at the valve shaft. It is lined with 15 ft. by 10 ft. concrete slabs, 6 in. thick. The sides slope at 3 : 1; a detail of the sides and floor is given in Fig. 27. Fig. 28 is a detail of the end of the apron or forebay. At the embankment the forebay ends in a retaining wall having a batter of 1 in 8, consisting of two side wings, and a central curved portion cut back into the embankment behind the valve tower. This may be seen in the views given. For this portion of the forebay the floor is raised to level 35·0 O.D.

The inner outlet shaft is octagonal in plan, as will be seen from Figs. 26, page 482, and 29, annexed. It is of concrete, with a normal thickness between the eight corner piers of 3 ft. 6 in., the main thickness of the walls being 8 ft. 6 in. The lower part is finished outside with plain concrete. From 60·0 O.D. upwards for nearly 10 ft. the exterior is finished with horizontal V joints, above which the facing is of Forest of Dean ashlar. The shaft is

finished with arching, a well-proportioned cornice and a Forest of Dean stone ornamental parapet.

The shaft is connected with the top of the embankment, as already described by a bridge of five arches, four of which are 18 ft. span and one of 14 ft. The arches are struck with a radius of 10 ft. 7 in. and have a rise of 5 ft.; the piers are 4 ft. thick by 13 ft. 6 in. wide. The bridge is finished with a parapet in keeping with that of the tower, and the general appearance of the work is excellent. The draw-off of the water of the reservoir is controlled at the inner shaft by seven single-faced sluice gates, 6 ft. high by 5 ft. wide, at various depths, the lowest being 2 ft. above the floor of the forebay. These are operated from the deck of the shaft, which is of reinforced concrete.

At the 32·0 O.D. the octagonal tower terminates, but the shaft is continued to 0·0 O.D. in rectangular form. Its inside measurements for this section are 14 ft. by 12 ft., and the concrete walls are 5 ft. thick. From the bottom of this shaft a circular tunnel 9 ft. 9 in. in diameter connects the inner with the outer shaft. This tunnel is built of cast-iron segments. It was driven without a shield. A view of it in course of construction is given in Fig. 36, annexed. The lower half is lined with concrete to the inside of the flanges, with thereon a facing of brindle brick on edge. The upper half is lined with concrete to the whole thickness, i.e., for 4½ in. inside the flanges. The tunnel has a length of 126 ft. 6 in. between the two shafts.

The outer shaft, as already stated, is placed just outside the puddle core. It is illustrated in Figs. 30 and 31, page 481, while Fig. 37 shows this shaft at one stage of its construction, with the puddle trench close alongside. The bottom portion of this shaft is similar to that of the inner shaft, viz., 12 ft. by 14 ft. inside with concrete walls 5 ft. thick. At the 24·5 O.D. level this changes to a shaft of 12 ft. by 22 ft. inside measurement in order to accommodate as shown in Fig. 31 two single-faced sluice valves controlling the entrance to two 8-ft. conduits placed side by side. These sluices are operated by gearing at the top of the shafts which is level with the top of the embankment. In the neighbourhood of the valve openings and in the opposite side of the shaft at this level, the concrete is reinforced with 1 in. horizontal bars. The whole shaft is surrounded by clay puddle which may be seen being built up in Fig. 37. This is carried down to and into the London clay. All sluices at the outlet are being supplied by Messrs. Ransome and Rapier, Limited, of Ipswich.

Details of the two 8-ft. conduits are given in Figs. 32 to 35, while Figs. 40 and 41, on page 483, show them under construction. The conduits are of reinforced concrete, and the two pipes formed side by side in one structure. Fig. 32 shows a detail of the manner in which the joint is made in the wall of the shaft, two key rings being formed in the latter, 4 in. deep, as a security against water creepage. Immediately outside the shaft wall is the deep concrete block shown in Figs. 32 and 33. This is carried down and into the London clay, and round its top and sides is also grooved to a depth of 12 in. to take a key of clay puddle. Beyond this key block, which is 5 ft. thick, the double conduit proper commences, the first 80 ft. being reinforced, as shown in Fig. 35, and the subsequent 125 ft. as shown in Fig. 34. The double reinforcement (Fig. 35) consists of outer circular rings of ¾ in. rods spaced 5½ in. apart with an overlap of the rod ends of 2 ft., and inner lengths of 7 ft. 6 in., arranged symmetrically at the top and bottom on the vertical axis. The longitudinal reinforcement is of ½-in. rod, spaced 12 in. apart, immediately inside the outer rings, and immediately outside the 7 ft. 6 in. lengths. In the single reinforced length only the complete outer rings with their corresponding longitudinals are used, the short inner lengths and inner longitudinal bars being omitted. The conduits are spaced 10 ft. centre to centre, and the whole forms a mass 20 ft. in width and about 10 ft. 6 in. thick.

The original contract placed as we stated in our previous article in 1914, was awarded to Messrs. Dick, Kerr and Co. The present contract has been placed on a cost plus lump sum basis with Messrs. S. Pearson and Son (Contracting Department), Limited. The excavation of the body of the reservoir is being carried out with two Lubecker excavators and two Ruston Proctor navvies. The pug mills and other machinery on the works are driven by electricity generated in stations on the site.

OUTLET WORKS OF THE LITTLETON RESERVOIR.

MR. H. E. STILGOE, M.INST.C.E., ENGINEER.

Fig. 36. Tunnel Connecting the Inner and Outer Shafts under Construction.

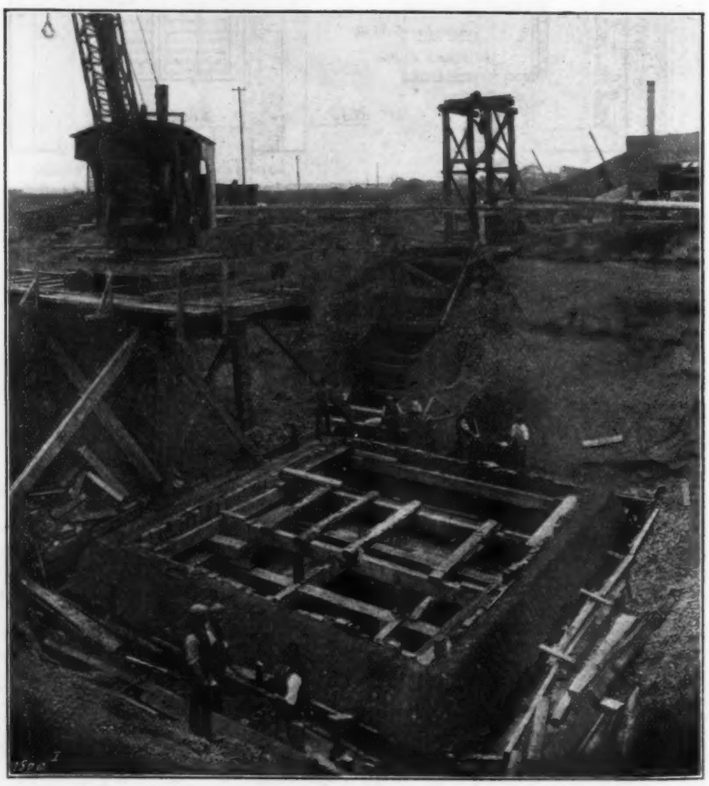


Fig. 37. The Outer Shaft under Construction.

Steel Lumber.—A product popularly known in the United States as steel lumber, has been developed for use as floor joists, owing to the scarcity of timber. The material consists practically of very light-weight joists. The process of manufacture consists of putting light-gauge steel strip, up to 17 in. wide, through a machine in which rollers work it to the form of a channel. Two channels, back to back, run on through a series of automatic spot welders, from which the joist passes on to high-speed trimming friction saws, finally being plunged into a paint dip. The rate of output of this steel lumber is said to be remarkable.

OUTLET WORKS OF THE LITTLETON RESERVOIR OF THE METROPOLITAN WATER BOARD.

MR. H. E. STILGOE, M.INST.C.E., CHIEF ENGINEER TO THE METROPOLITAN WATER BOARD, ENGINEER.

(*For Description, see Page* 481.)

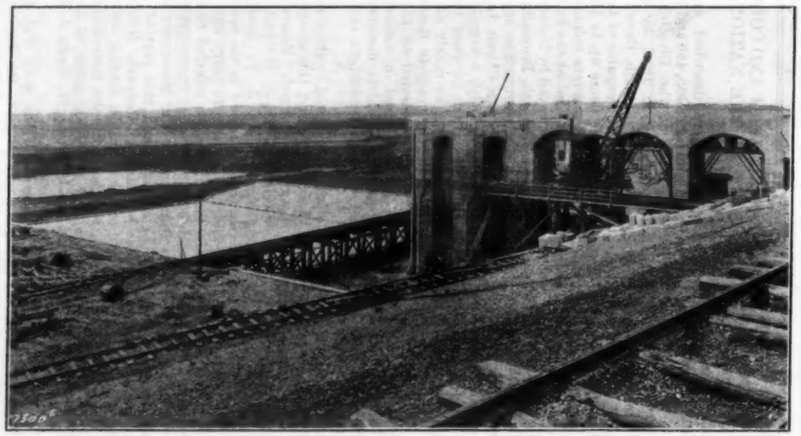


FIG. 38. THE INNER SHAFT AND FORE BAY.

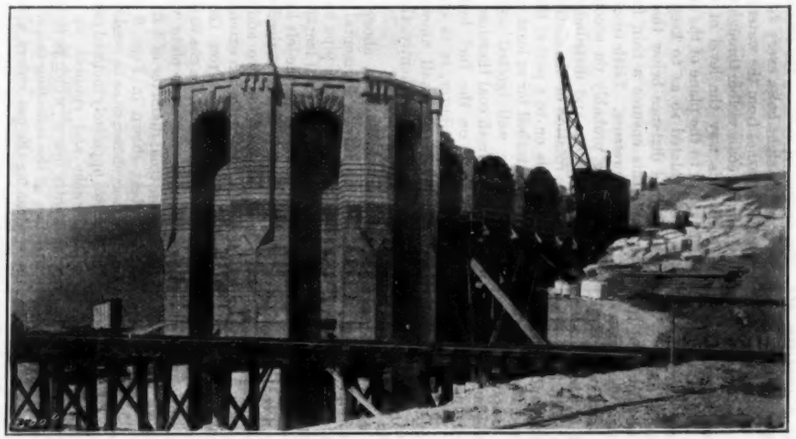


FIG. 39. THE INNER SHAFT LOOKING TOWARDS EMBANKMENT.

FIG. 40. THE CONDUITS LEADING OFF THE INNER SHAFT.

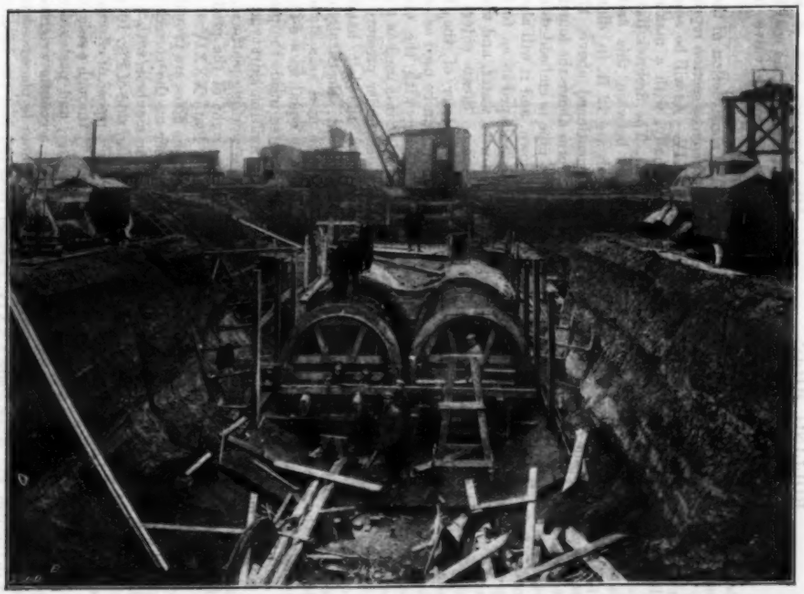


FIG. 41. THE REINFORCED 8-FT. CONDUITS UNDER CONSTRUCTION.

THE MOSSEND STEEL WORKS AND ROLLING MILLS.

(*Continued from page* 448.)

It will be both logical and convenient to commence our detailed description of the plant with an account of the producers which supply gas to the steel furnaces. These, as previously stated, are 36 in number, and are arranged in one straight line parallel with the furnaces, in three groups of 12 each. They are shown in the photograph reproduced in Fig. 5, on page 494, and also in the side elevation and plan, Figs. 9 and 10, on Plate XXXIV, which accompanies this issue. The complete producer plant was designed and built by the International Construction Company, Limited (successors to Julian Kennedy, Sahlin and Company, Limited), of 56, Kingsway, London, to supply gas from Scottish coals for fifteen 50-ton Siemens open-hearth furnaces. An additional furnace has, however, been installed without increasing the producer plant.

The producers are of the standard Morgan type adapted for using Scottish coal, of which they are each capable of gasifying from 12 tons to 15 tons per day of 24 hours. As is best shown in the cross section, Fig. 7, on Plate XXXIV, the producers are mounted on concrete foundations raised 5 ft. above the level of the heads of the rails in the yard, and are installed in a steel framed building, the sides and ends of which are open. The total length of this building, measured between the centre lines of the end columns, is 672 ft., this length being made up of 42 bays of 16 ft. each; the width of the building, also measured between the centre lines of the columns, is 14 ft. The columns, which are each composed of a pair of braced channels, have a total height of 44 ft. 3 in., and they carry the roof, which is covered with black corrugated sheets, the crane track, the coal hoppers mounted over each of the producers, and also the working platform. The latter is erected at the level of the tops of the producers, 12 ft. 3 in. above the foundations, and is accessible by means of several stairways placed as shown in the plan, Fig. 10, on Plate XXXIV. Parallel with the producer foundation, and quite close to it on each side, is a narrow-gauge railway track, on which run small tipping wagons for handling the dust and ashes, while farther away on each side are standard gauge tracks for the trucks delivering coal.

The coal is stored in two deep pits constructed of reinforced concrete with sloping sides and situated one between each group of 12 producers, as shown in Figs. 9 and 10; a cross-section of one of the pits, drawn to a larger scale, is also given in Fig. 6. The pits, which each occupy three bays of the producer building, are 48 ft. square at the top and measure 40 ft. by 12 ft. at the bottom, while their total depth is 30 ft. from the top of the producer foundations. The coal tracks are carried over the edges of the pits and the wagons are tipped endwise by means of hydraulic tippers so that the coal falls through horizontal grids, having a 4-in. mesh, into the pits; there are two hydraulic tippers to each pit, one being placed on each side, as shown in the plan Fig. 10. The centre part of one of the pits, that on the right in Figs. 9 and 10, is walled off to form an ash bunker and the ashes from the producers are tipped into this bunker from the small tipping wagons above referred to. The ashes are removed from the bunker by means of a 5-ton electric crane fitted with a grab bucket and running on a gantry constructed at right angles to the length of the producer building, as shown in Fig. 6. They are delivered by the crane into side-tipping wagons and transported in these wagons to the ash dump. It should, perhaps, be explained that the method of ash handling just described has been adopted since the photograph of the producers, reproduced in Fig. 5, was taken, and this accounts for the fact that the gantry for the ash handling crane does not appear in that illustration. Coal is lifted from the storage pits by means of two cranes of similar design to those used for handling the ashes, but running along the whole length of the producer building on rail girders supported by the columns. These cranes are provided with lifting and longitudinal travelling motions only, and they are controlled from a cab suspended under the crane bridge as shown in Figs. 6 and 7. The coal is dumped by the cranes into hoppers of pyramid form, one of which is fixed over each of the producers. From the hoppers, each of which has a capacity of about 20 tons, the coal falls by gravity through a hand-controlled valve into the hoppers of the producers.

The construction of the producers is well shown by the cross section reproduced in Fig. 8, on Plate XXXIV. As will be seen, they are barrel shaped internally, with a maximum internal diameter of 10 ft. The firebrick lining is 9 in. thick, and the space between this and the outer shell plates, which are 12 ft. in diameter, is filled with sand. As mentioned above, the height of the working platform above the foundations is 12 ft. 3 in. The blast pipe is embedded in the concrete foundation, as shown, and it will also be noticed that the concrete is shaped so as to form an ashpit, which is filled with water, and thus seals the bottom of the producer. Steam enters the blast pipe through a spiral injector of the Koerting type, which, if desired, can be used as an aspirator for air without interfering with the operation of the producer. Normally, it is used as a steam inlet only, air being supplied under pressure through the vertical pipe seen on the left hand side of Fig. 8. Four Sturtevant electrically-driven blowers, one of which is used as a stand-by, supply the air at a pressure equal to a 5-in. water column, and it is distributed inside the producer by a conical tuyere of the multiple skirt type. The blowers are mounted on the working platform, and can be distinguished to the right of the producer in the cross section, Fig. 6, Plate XXXIV. As shown in Fig. 8, sight and poke holes are provided round the shell of the producer at the correct height above the tuyere, and the manhole, with a steel cover, shown on the left hand side of Fig. 10, gives access to the interior for the purpose of effecting repairs. Gas leaves the producer through a side outlet, 2 ft. 9 in. in internal diameter, and passes directly into a dust catcher having a counter-weighted bell door at the bottom. This door is placed centrally over the ash track, so that the dust can be dropped directly into wagons running on this track.

The most interesting feature of the producers, and one on which they depend largely for efficient working, is the J. R. George automatic feed and fuel distributor, with which they are fitted. The apparatus, which is supported from the top of the producer by three cast-iron standards, comprises a small receiving hopper, a fuel chamber separated from the hopper by a counter-weighted bell, and a revolving water-cooled distributor which extends into the producer as shown in Fig. 8. Gas-tight joints between the revolving and stationary parts are made by means of water seals. The rotary distributor is driven by ratchet and pawl mechanism, which is shown dotted in Fig. 8. The pawl is reciprocated by means of an eccentric mounted on an overhead shaft, and, by altering the position of the end of the eccentric rod in a slotted link attached to the pawl, the stroke of the latter can be adjusted to give the desired rate of feed. As the distributor rotates, coal gradually falls from the fuel chamber on to a horizontal spreader disc moving with the distributor, and, being pushed off this disc by means of a fixed scraper, it falls on to the spout of the distributor, and thence into the producer. The spout is provided with two adjustable bars, the position of which can be varied to alter the distribution of the fuel. By this means a thin stream of fuel is continuously scattered over the whole surface of the fuel bed in the producer, and this has the obvious advantage that the quality of the gas is not affected by the admission of fuel at intervals as is the case with the ordinary bell and hopper feed commonly employed. Another advantage of the George feed over the earlier form is that, with the latter, the fine coal usually falls towards the centre of the producer and the larger pieces towards the side walls. The effect of this is to allow most of the blast to pass up near the walls, and, unless the fire is constantly stirred by poking, large clinkers tend to form in the centre. These act as a cap over the tuyere and allow "chimneys" to form in the fuel bed through which unconsumed oxygen can pass into the gas space of the producer where it burns to CO_2. Not only does this waste fuel in the producer, but it has the effect of lowering the flame temperature when the gas is burned in the steel furnaces.

The method of working the producers at Mossend is to open the sight holes every 24 hours, and rake out sufficient ashes from the water-sealed ash pit to leave glowing coals visible through each of the sight holes. In this way the level of the fire zone is brought down to the plane of the sight holes. The feeds are regulated so as to keep the fuel bed a predetermined distance below the top of the producer, and this ensures a thin fire, hot gas and uniform blast pressure. Little trouble is experienced with clinkering, probably on account of the continuous admission and distribution of the fuel. Owing to the rotation of the distributor, the fresh coal always falls on to a part of the fuel bed which has been undisturbed for at least ten minutes, and is consequently well ignited and partly turned into ash. The fresh coal therefore does not adhere to that already on the fuel bed. Due to this action of the distributor, it is only necessary to use a comparatively small amount of steam in the blast, and consequently the percentage of hydrogen in the gas is low.

From the dust catchers, above referred to, the gas passes up into a horizontal collecting main, which is a brick-lined steel pipe having an internal diameter of 6 ft. and a total length of 860 ft. This main is clearly visible on the left hand side of Fig. 5 on page 494, and it will be noticed that connections have been provided for two additional producers which will be installed when extensions to the plant render them necessary. From the collecting main, 16 cross-over pipes lead the gas to the steel furnaces. These pipes are of steel plate with brick lining giving an internal diameter of 4 ft., and their form, which is best shown in Figs. 6 and 7, on Plate XXXIV, was chosen so as to render them self-cleaning. The two oppositely inclined portions span three railway tracks and connect up with a vertical leg the centre line of which is 40 ft. 6 in. from the centre line of the collecting main. At the foot of the vertical leg the gas enters a brick flue, which passes under the floor of the marshalling shop and leads through Dyblie reversing valves to the furnaces in the melting shop.

(*To be continued.*)

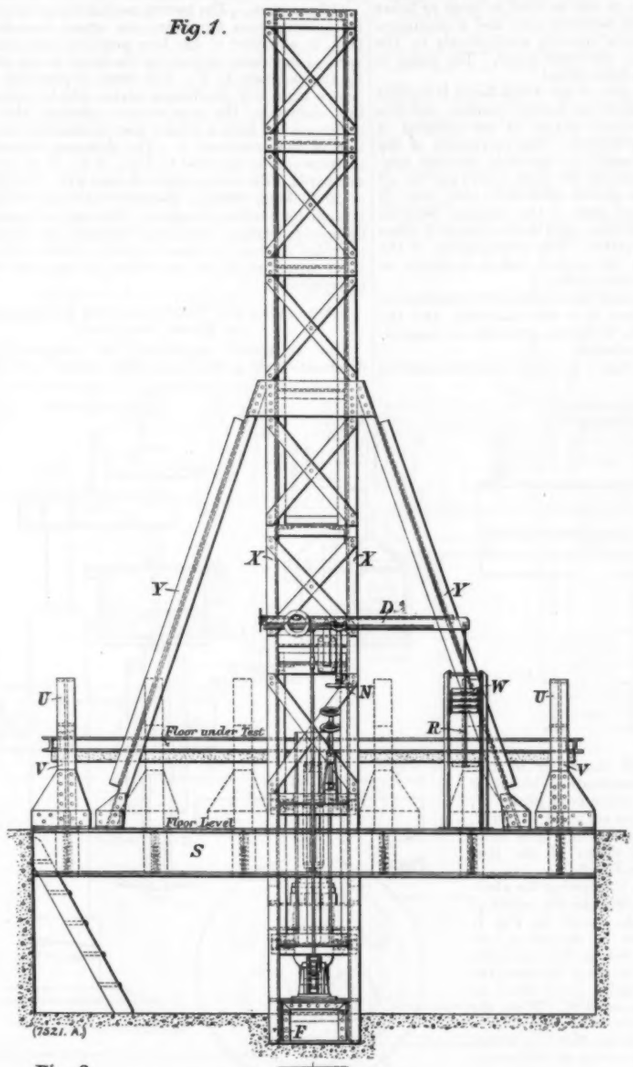
FLOOR SLAB, BEAM AND COLUMN TESTING MACHINE AT THE NATIONAL PHYSICAL LABORATORY.

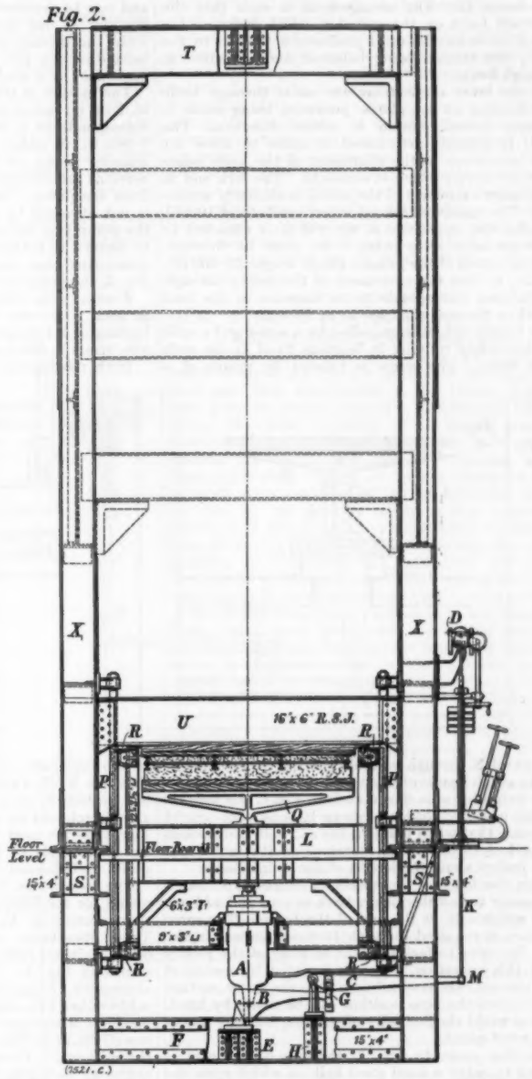
The machine here described and illustrated by the engravings on pages 485, 486 and 487, is the outcome of an offer made to the Director of the National Physical Laboratory in 1914, by Sir John Cowan, chairman of Messrs. Redpath, Brown and Co., Limited, that a testing machine capable of tests to destruction of steel and concrete floors up to 16 ft. long by 6 ft. wide, and steel and concrete columns up to 20 ft. in height should be installed at the Laboratory, the cost of which would be defrayed by Messrs. Redpath, Brown and Co. Messrs. Redpath, Brown and Co.'s immediate object in presenting the machine arose from the desire on the part of Sir John Cowan to have carried out by an independent body, a complete series of tests on the smaller sections of steel joists embedded in concrete, representing as nearly as possible the conditions met with in concrete floors. Further, since reliable figures were wanted for the strength of steel H-section columns cased in concrete it was decided that the machine should be designed so that columns and other structural members could also be tested on it.

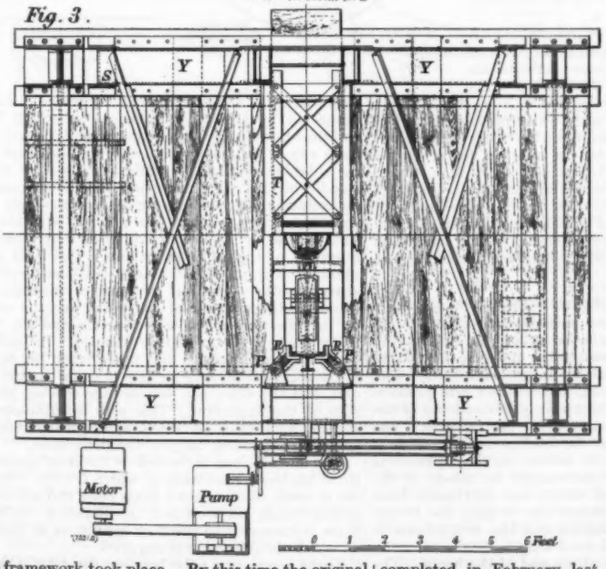
This offer was accepted by the Executive Committee of the Laboratory, and the design of the proposed machine was put in hand. Messrs. Redpath, Brown and Co. called in Mr. J. Mitchell Moncrieff, C.B.E., M.Inst.C.E., and Mr. J. R. Sharman, M.Inst.C.E., to advise them in regard to the machine and the tests it would be desirable to carry out on it in order to obtain the information referred to above. Mr. Sharman designed the steel framework of the machine in consultation with Mr. Moncrieff and the staff of the Laboratory, and this part of the machine was made by Messrs. Redpath, Brown and Co. The design of the hydraulic loading and measuring appliances, together with the instruments for the determination of the deformation of the specimens was carried out by Mr. J. H. Hyde, A.M.Inst.C.E., of the Laboratory staff.

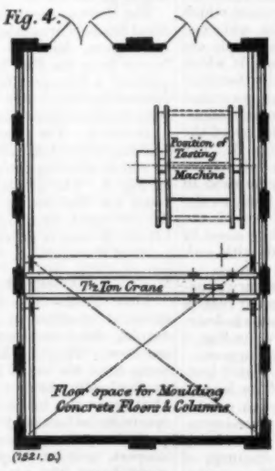
The progress of the work was naturally impeded during the war owing to the demands of more urgent work, and it was not until April, 1920, that delivery

FLOOR SLAB, BEAM AND COLUMN TESTING MACHINE.









of the framework took place. By this time the original site for the machine had been occupied by other apparatus and, consequently, the erection of the machine was further delayed until a suitable building for housing it could be erected. The erection of the machine in the new building was finally completed in February last. The results of a preliminary series of tests on specimens of steel joists and reinforced concrete flooring and on 16 ft. columns cased in concrete have shown that the machine is well suited for its work, and it is considered a valuable addition to the research equipment of the Laboratory.

Description of Machine.—The machine is arranged to accommodate a floor specimen of a maximum width of 6 ft. and a maximum thickness of 14 in., on a span of 4 ft., 9 ft. or 14 ft., as desired. The specimen is tested in an inverted position, the ends abutting against the underside of rigid cross-beams; the load is supplied vertically upwards, across the specimen, and midway between the abutments. Columns of 8 ft., 12 ft., 16 ft. and 20 ft. long can be accommodated and tested in a vertical position. The maximum load which can be exerted by the machine is 60 tons. The general arrangement is shown in Figs. 1, 2 and 3.

Loading and Load-Measuring System.—The loading system is best shown in Fig. 2, in which A is a hydraulic cylinder, B a primary or main lever, C a secondary lever, and D a measuring lever fitted with a jockey weight. The cylinder is provided at the bottom with a long knife-edge plate which rests on a knife-edge rigidly fixed to the main lever B. The knife-edge fulcrum of this lever rests on a bracket which is supported by the diaphragm E of the cross-beam F, the latter being a part of the main frame. The long arm of the main lever is connected to the second lever C by means of a link G and the fulcrum of the secondary lever is supported by a bracket which rests on a second diaphragm H, of the cross-

beam F. To the end of the longer arm of the second lever is attached a vertical rod K, the upper extremity of which is attached to the end of the short arm of the weigh-beam D. The arrangement is such that the downward force on the cylinder, which balances the upward force on the ram, produces a tension in the rod K, this tension being balanced and measured at the weigh-beam.

All the lever connections are made through knife edges bearing on flat plates, provision being made to eliminate lateral motion in either direction. The link G is suitably articulated in order to allow for slight inaccuracy in the alignment of the knife edges of the two levers which it connects. The fork end M at the lower extremity of the rod K is similarly articulated. The main and second levers are both of 10 to 1 ratio, and the upper end of the rod K is attached to the weigh-beam at a point 5 in. from its fulcrum. The total travel of the jockey, which weighs 22·400 lb., is 50 in., so that the movement of the jockey through this distance corresponds to an increase in the load exerted by the ram of 22,400 lb. or 10 tons.

The jockey-weight is propelled by a screw and a split nut, the former running in bearings fixed at the ends of the beam. The screw is rotated by means of a hand wheel N through suitable gearing in the manner usual in weigh beams of this type.

The weigh-beam is shown at D in Fig. 1, the weights W being provided for loads above 10 tons, each weight being such that when hung on the rod R it corresponds to a load of 10 tons, and, therefore, to the movement of the jockey along the length of the weigh-beam.

When the load on the specimen exceeds 10 tons it is necessary to run the jockey back to zero and add one of the weights W at the end of the beam. The same procedure is required for each 10 tons increase in the load. In order to facilitate the shifting of the jockey during this operation, a device is fitted by means of which the nut can be withdrawn from the screw, so that the return to the zero position can be made by hand, and thus avoid the necessity of winding back by means of the hand wheel.

Referring again to Fig. 2, the top of the ram it recessed to carry a hard steel ball on which rests the cross-head L. The latter consists of a deep joist which carries, at either end, vertical channels 12 in. wide and 3 in. deep, and the extremities of these channels are provided with brackets fitted with vee rollers R which guide the crosshead vertically and laterally between four vertical posts P. Adjustments are provided on both posts and the rollers whereby accurate alignment may be rapidly obtained. The positions of the rollers and guides are shown in plan in Fig. 3. The loading beam Q (Fig. 2) rests on the top of the crosshead, the bearing surface being made cylindrical in order to allow the beam to tilt and align itself to the surface of the floor specimen. The surfaces of the loading beam and the abutments where they come in contact with the specimen, are provided with oak liners which are rounded off to a radius of 9 in.

Two-Point Loading Arrangement.—Preliminary experiments made on the machine have indicated that in certain cases two-point loading of the specimen is desirable, and consequently the arrangement shown in Figs. 5 and 6, annexed, has been adopted for this purpose.

The crosshead L (Fig. 2) is replaced by a stiff box-girder A which rests, across the centre of its length, on a semi-cylindrical bearing. The girder A carries two rocking beams, similar to Q (Fig. 2), placed symmetrically on either side of the centre, the girder being drilled to accommodate these beams at distances of 16 in., 36 in. and 56 in. apart as desired. The arrangement enables the loading beams Q to accommodate themselves to any initial twist in the specimen under test and at the same time ensures that each shall exert half the total load applied.

Control.—Oil is used as the hydraulic medium, and oil under pressure is supplied to the cylinder, through suitable control valves, by a special eight-cylinder Hele-Shaw hydraulic pump supplied by Messrs. Hydraulic Gears, Limited. The pump is of variable stroke and can be reversed; it can be used to raise or lower the ram at any speed between zero and a maximum with the driving motor running continuously in the same direction and at the same speed. The pump is controlled by a single hand wheel.

The motion of the end of the weigh-beam is limited to 1 in. on either side of its neutral position, and this corresponds to a vertical motion of the cylinder of 0·001 in. in either direction. The movement of the cylinder being so small, no specially flexible connections are introduced in the pipe conveying the oil from the pump; the pipe is allowed to hang free—it is not attached to any part of the machine between the pump and the cylinder—and the resistance it offers to flexure is inappreciable. The arrangement of the connecting pipe and the control valves is shown in Fig. 2, the pump is shown in Fig. 3.

Frame.—The frame of the machine is constructed in such a manner that it is self-contained, and the loading of a specimen, therefore, produces no appreciable stress in the foundation.

With reference to Figs. 1, 2 and 3, the frame consists of two uprights, each consisting of two channels X, X, two longitudinal beams of box section S, S, a lower cross-girder F, already referred to, and an upper girder T. The latter is used for column tests only, and can be placed in either of the four positions indicated in Fig. 2.

The cross-beams U, U, forming the abutments for the floor specimens are bolted to short stanchions V, V, shown in Fig. 1. These stanchions can be moved to two other positions indicated by the bolt holes shown in Fig. 3. The span between the abutments, longitudinally, can thus be made either 4 ft., 9 ft. or 14 ft. When the machine is arranged for tests on columns the struts Y, Y, Fig. 1, are fitted to stiffen the uprights. These struts are braced by angles as shown in Fig. 3.

The lower cross-girder F and the longitudinal beams S are embedded in the concrete foundation, but the space between the beams from the floor level to the top of the girder F is left open, forming a pit. The pit is suitably covered by removable boards, which prevent the *debris* from the specimens from falling on the lever system below.

Building.—The machine is erected in a special building 50 ft. long, 30 ft. wide and 28 ft. high, a plan of which, showing the position of the machine, is given in Fig. 4. The available floor space allows sufficient room for the casting of specimens and for storage. An overhead, hand-operated crane, with a maximum lift of 7½ tons, is provided for handling specimens and parts of the machine.

Method of Operating Machine.

Floor Tests.—The floor specimens are cast in an inverted position in order to avoid the necessity of turning them over before placing them in the testing machine. They are lifted by means of a steel frame hung from the crane hook, and lowered into position on the loading beam; the upper girder and one of the abutments has to be removed for the purpose. The specimen is balanced on the loading beam, which is packed up to prevent it rolling on its cylindrical support, and its weight ascertained by means of the weigh-beam, the zero of which has previously been determined. After obtaining the weight, the jockey is placed in its zero position and the weigh-beam is again balanced by small dead-weights which are hung on a scale pan provided at the end of the beam. The ram is then raised until the floor comes in contact with the end supports, the packing, if any, is adjusted and the test commenced. Deflections of the specimens are taken for equal increments of load, the increment depending upon the strength and nature of the floor specimen.

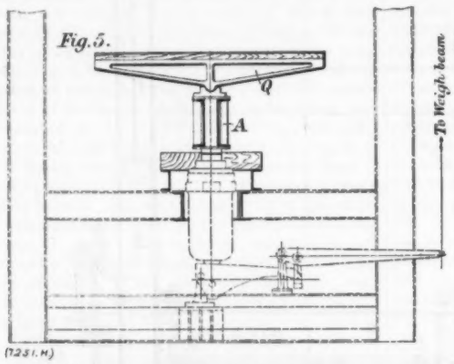
Column Tests.—The testing machine may be arranged for column tests by fitting the upper cross-beam T (Fig. 2) at either of the four positions indicated, the vertical members supporting the beam being stiffened by the channels Y, Y. The beam is provided at the centre with stiff diaphragm plates which support, on the underside, the compression platten, the latter corresponding with a similar platten fixed to the upper side of the crosshead L. The distance between the plattens can be adjusted to 9 ft., 13 ft., 17 ft. or 21 ft., as desired, to accommodate columns 8 ft., 12 ft., 16 ft., or 20 ft. long, with an allowance of 6 in. at top and bottom for loading brackets. Two sets of compound knife-edge loading brackets, referred to later, are provided for tests on pivot ended columns, the maximum capacities of the sets being 15 tons and 50 tons respectively.

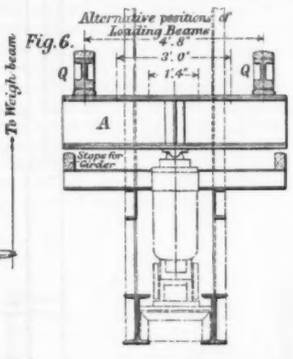
Apparatus for Measuring the Deflection of Floor Specimens.

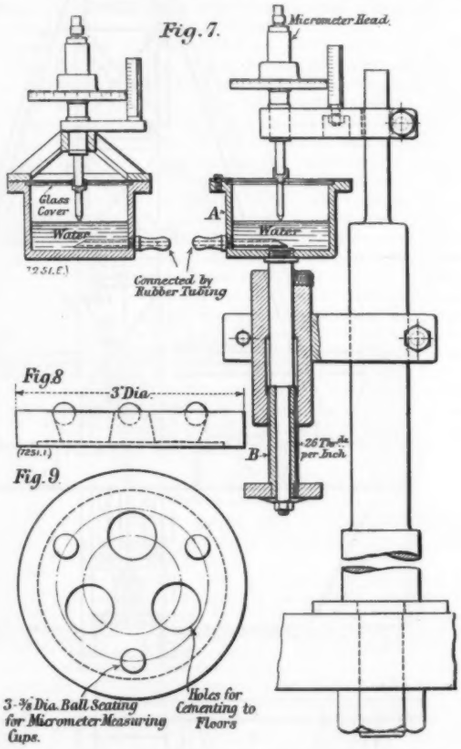
The apparatus employed for determining the deformation of a floor specimen under load consists essentially of a water level comprising two cups, connected by a flexible tube, one of which is fixed and the other resting on the surface under examination. Each cup is provided with a micrometer which is held by a bridge piece in a vertical position so that the spindle of the micrometer is co-axial with the cup. By rotating the micrometer sleeve the end of the spindle may be brought into contact with the water surface, the level of which is thus determined with reference of the micrometer zero. The level may be obtained with ease to within 0·0005 in. by fitting a sharp needle point on the end of the micrometer spindle; the advance of the point may be observed by its reflection in the water surface and the instant of contact is very sharply defined. In using the apparatus, readings are first taken when the specimen is resting on the floor in the position in which it is cast, and the difference between the reading gives the zero of the apparatus. This zero is subtracted from similar differences obtained subsequently when the specimen is loaded, to give the deflections.

The movable cup is located on the floor specimen by three hardened steel balls on which it rests. The balls are securely riveted into a brass plate and are arranged symmetrically on a circle 2 in. diameter. A location plate is cemented to the floor specimens at each point at which the deflection is required.

If the connecting tube between the cups is made up of lengths of stout glass tube joined by short pieces of rubber pressure-tubing the micrometer on the fixed







cup may be dispensed with, provided that the readings are taken in a reasonable time to avoid inaccuracy due to evaporation of the water. In this case the deflection measurement can be made to an accuracy of 0·005 in.

The apparatus is shown in Fig. 7. The fixed cup A is mounted on a screw B, so that its height may be adjusted when the deflection of the specimen is great. This obviates the necessity for using very deep cups. Figs. 8 and 9 show the plate, with the three steel balls, which is cemented to the floor specimen to locate the position of the movable cup.

APPARATUS FOR THE LOADING AND THE MEASUREMENT OF THE STRAIN OF COLUMN SPECIMENS.

Loading.—The loading plattens on the testing machine are machined flat and set as nearly parallel as the construction of the machine allows. It is expected, however, that the ends of flat-ended columns will need to be faced with neat cement or other packing in order to distribute the load equally over the area of the ends.

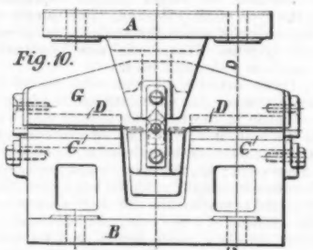


Fig. 10.

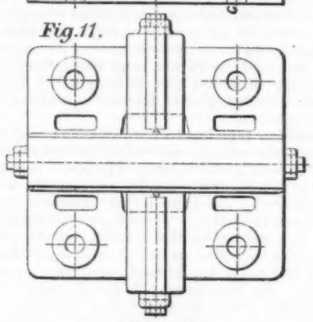


Fig. 11.

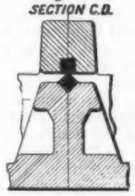


Fig. 12. SECTION C.D.

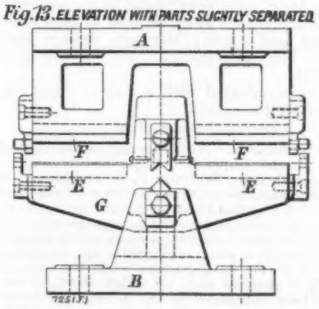


Fig. 13. ELEVATION WITH PARTS SLIGHTLY SEPARATED.

For pivot-ended columns special fittings have been devised with the object of reducing the pivot friction to a minimum and of defining with a high degree of accuracy the point of application of the load.

The end fitting is shown in Figs. 10 to 13 and consists of two brackets A and B, one being fixed to the machine platten and the other to the end of the column. Each bracket carries two knife-edges C, C, and F, F, which bear respectively on suitable plates D, D, and E, E, fixed in the central cross-piece G. The knife-edge plates are so arranged in the cross-piece that the bearing surfaces lie in the same plane. The complete fitting thus forms a universal pivot, the point about which motion takes place being the point of intersection of the lines through the knife-edges in the plane containing the bearing plates.

Two sets of fittings are provided, one for a maximum load of 15 tons, in which the distance from the pivot point to the end of the column is 3 in., and one for a maximum load of 50 tons with a distance of 5½ in. from the pivot point to the end of the column. The fittings thus increase the length of the column by 6 in. and 10½ in. respectively, for the two sizes. The knife-edges are of such a length that the maximum load per inch of edge is about 5 tons; each knife-edge is made of square steel, so that four edges are available should the flattening under heavy load become excessive.

Measurement of Strain.—The shortening of the column under load is measured at four points arranged symmetrically with the axis of the column and either at the centres of the sides or at the corners of a square of 16-in. side.

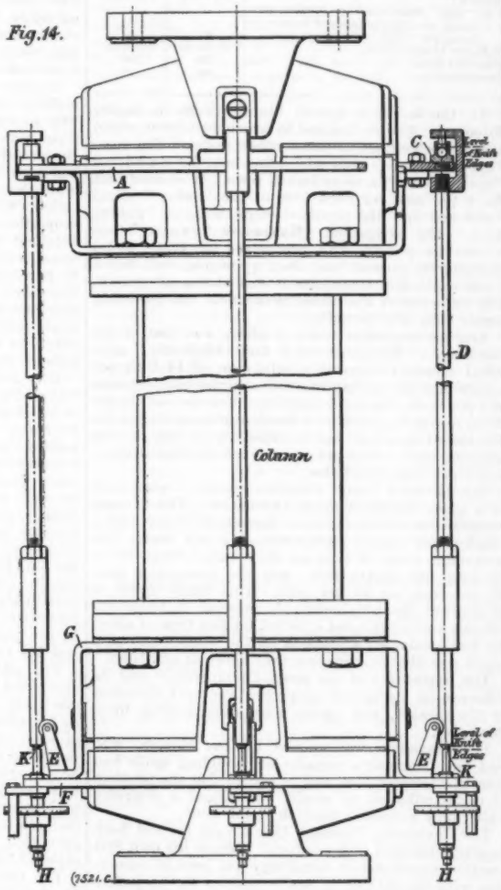


Fig. 14.

The arrangement of the apparatus is shown in Fig. 14. The plate A is secured to the pivot bracket at the top of the column and carries four sockets C containing hardened steel balls. These balls support the upper ends of four rods D, the lower extremities of which are guided by brackets E fixed to the plate F at the foot of the column. The plate F is secured to the lower column pivot bracket by the plates G, and supports four micrometers H, arranged directly under the ends of the rods D. Suitable adjustments for the lengths of the rods D for small variations in the lengths of columns of the same nominal size are provided, and the rods are fitted with hardened steel balls K where contact with the top of the micrometer spindle takes place. The micrometers may be replaced by dial indicators in order to obtain direct readings.

Preliminary experiments have shown that the temperature of the air in the test-house in the neighbourhood of the column remains appreciably constant during the time taken to carry out a test, provided the doors and windows of the building are kept closed and the apparatus is protected from the direct rays of the sun, and from draughts.

Measurements taken on the micrometers on unloaded columns 16 ft. long at 10-minute intervals over a period of 1½ hours, remained constant within 0·0002 in., and, consequently, no special precautions, other than those mentioned above, have been taken with regard either to minimising the variation in temperature of the apparatus and column, or of the measurement of the effect of such variation.

In carrying out a test the readings of all four micrometers are taken at zero load and at successive increments of load up to the highest value obtainable without risking damage to the micrometers. The amount of shortening of the column for any load is obtained by taking the mean value of the difference between the micrometer readings at that load and zero load. From the individual micrometer readings the relative inclination of the ends of the column when bending occurs, and the direction of the axis about which the inclination takes place can be readily determined. It has been found that a column under test may bend about an axis considerably inclined to the nominal axis of least moment of inertia of the section during the initial stages of loading.

NEW BARTON POWER STATION OF THE MANCHESTER CORPORATION.

THE Manchester Corporation has, we believe, the credit of supplying a larger amount of electrical energy than any other municipality in the United Kingdom. Last year its output exceeded 158,000,000 kilowatt-hours, the plant capacity of its three generating stations aggregating 128,450 kilowatts. As is generally known, the Corporation are now erecting another large generating station at Barton, designed for an ultimate accommodation of 150,000 kilowatts of plant. In view of the interest taken in this station, the members of the Manchester Association of Engineers were given the opportunity of inspecting the work in progress on Saturday last, and over 200 availed themselves of the privilege. The site of the station covers over 14 acres in Trafford Park, on the south side of the Bridgewater Canal, and close to the Manchester Ship Canal, from which the condensing water will normally be drawn. A further source of condensing water is available in the purified effluent from the outfall sewer of the Corporation. The condensing facilities, which are quite the most important consideration in connection with power-house sites, are excellent. The circulating water enters and leaves the station through two circular culverts, each 9 ft. 6 in. in diameter, and the electrically-driven circulating pumps, of which there are two to each condenser, are about 50 ft. below the level of the canal.

The turbine room is 243 ft. long by 65 ft. wide, and will contain at first three turbo-alternators, each rated at 27,500 kilowatts continuous output, at a speed of 1,500 revolutions per minute. The generators deliver three-phase current at 6,600 volts and 50 cycles, the pressure being raised to 33,000 volts for transmission to the city. The turbines take steam at 350 lb. per square inch, superheated to 700 deg. Fahr., and, as the condensing plant is designed for a vacuum of 29·1 in. of mercury at full load, the station should be one of the most economical in the country.

The boiler house is 314 ft. long by 87 ft. wide and 86 ft. high. It will contain nine Babcock and Wilcox marine-type boilers, fitted with double-firing furnaces. Each boiler, together with its chain grate stokers, superheater, economiser, air heater, chimney and fans for forced and induced draught, forms a complete unit in itself, capable of supplying 100,000 lb. of high-pressure steam per hour when working at its most economical rate. The boilers are guaranteed able to furnish 120,000 lb. of steam per hour each, when supplied with coal of not less calorific value than 10,500 B.Th.U. per pound. The disposal of ashes is always one of the most serious problems of power-house operation, and Mr. S. L. Pearce, the electrical engineer to the Manchester Corporation, has, we think, done the wisest thing in dispensing with ash conveyors or elevators of every kind at Barton. The boiler house is built, as it should be, without a basement, so that standard-gauge railway wagons, or road vehicles, can be run right under the ash hoppers of the boilers to receive the ashes. The first section of the station will not be completed before the end of 1923, but it is hoped that by next March work will be sufficiently advanced to enable some load to be carried. The Manchester undertaking comes under the same Joint Electricity Authority as that of the East Lancashire Power Company, and it will be interesting to note how the Barton results compare with the particularly good figures which are obtained at the company's station at Radcliffe.

SEWAGE LIFTING PLANT, SOUTH AFRICA.—The Imperial Trade Correspondent at Port Elizabeth reports that the City Council of the Municipality of the City of Port Elizabeth are prepared to receive tenders for sewage-lifting plant, either of air ejector or pump type for one of the drainage area pumping stations. A copy of the particulars concerning the supply and erection of the sewage-lifting plant required, and tender forms, can be consulted at the Department of Overseas Trade (Room 50), 35, Old Queen-street, S.W. 1, by United Kingdom firms who may be interested.

NON-FERROUS FOUNDRY PRACTICE.

The annual general meeting of the Sheffield Local Section of the Institute of Metals was held at the University, Applied Science Department, on Friday last, the 13th inst. Professor Cecil H. Desch, D.Sc., occupied the chair. After disposing of the ordinary business, Dr. Percy Longmuir was called upon to deliver a lecture on "Non-ferrous Foundry Practice."

Dr. Percy Longmuir said that there had recently been formed in Sheffield a trade technical society called "The Foundry Trades Technical Society." By way of preface, he would like to state that the objects of such societies were two-fold. Firstly, to attract men who were not attached to any of the greater technical societies, such as the Institute of Metals, and, secondly, to encourage young men engaged in technical trades to become students at the University. He felt sure that such technical societies had a place to fill, and that there would be no rivalry between the smaller and the larger bodies, but rather that the former would act as feeders for and ultimately increase the membership of the latter.

The starting-point in foundry practice was, of course, the mould. Successful mould-making of any description depended on successful core-making, and the closest possible association should exist between the patternmaker and the foundry man. If this condition of affairs could be brought about, it was astonishing what good work could be done. The success and further development of machine moulding was absolutely linked up with the development of core-making. Refractories were not used to such an extent in non-ferrous as they were in ferrous foundry practice, but moulding sands were of foremost importance. There was an enormous amount of research on moulding sands yet to be carried out. The work accomplished up to the present was chiefly useful because it had opened the way to further research.

To illustrate the intricate problem of the use of moulding sands, he would mention one difficulty only. If two moulds were made of the same sand, identical in all respects, and filled up, one with molten lead at a temperature of 450 deg. C., and the other with molten "Admiralty" gunmetal (of composition 88 per cent. copper, 10 per cent. tin, 2 per cent. zinc) at a temperature of 1,100 deg. C., the resultant castings would by no means be identical in appearance. The gunmetal casting would have a perfectly smooth surface, while that of the lead would be roughened by adhering particles of sand. Consequently, it was clear that, in considering moulding sand, pouring temperature alone was not the only factor, but that the penetrating or searching action of the metal into the mould had always to be taken into account.

In many brass foundries too little attention was paid to loss of zinc by volatilisation. That loss should always be allowed for and made good. Another essential feature was quick melting. A copper, zinc, tin (or copper, zinc) alloy should invariably be melted as quickly as possible, and in no case should the heat be kept waiting in the furnace in the molten state until the moulders were ready to receive it. Correct organisation was absolutely essential.

When copper, zinc and other virgin metals were purchased, no check was possible in many brass foundries; this was especially true in the case of the smaller concerns. Wherever practicable, all virgin metals should be checked by some such means as chemical analysis or the application of mechanical testing. To show the importance of checking purchases, analyses of commercially pure metals should be considered. For instance a typical analysis of commercial copper showed:—

	Per cent.
Copper	99·29
Arsenic	0·46
Tin	trace
Lead	0·18
Iron	trace
Zinc and silver	trace

Ingot zinc and ingot lead gave analyses as follows:—

Ingot Zinc.	Per cent.	Ingot Lead.	Per cent.
Zinc ...	99·890	Lead ...	99·63
Lead ...	0·090	Antimony	0·08
Iron ...	0·014	Tin ...	0·14

The accurate weighing of charges was of great importance, and full and systematic foundry records should be kept.

A very important question was the question of scrap. Different classes of scrap should be kept in separate boxes in the foundry. Each box should be plainly marked and this logical rule rigorously enforced. He went even further and advised that the turnings in the machine shop attached to the foundry should also be kept separate. That was more difficult, but experience proved that, in a machine shop dealing with an average of 10 tons of non-ferrous material per week, it paid to keep a man solely engaged in the recovery of turnings, by sweeping down the machines before a change of metals was made. The problem of scrap was far greater in a non-ferrous than in an iron foundry, but care in keeping the various grades of scrap separate was a distinct advantage from a financial point of view.

Considering the scientific aspects of foundry practice, one often wondered what fluidity really was. The term used in the trade was "running-power" and as, in most cases, a high running power was very desirable, any research on the subject was very much appreciated by practical men, and proved a real help.

With regard to composition of various brasses, the following table might be given as typical:—

Name.	Copper.	Zinc.
Ormolu:	Per cent.	Per cent.
A "red" brass used for brazing purposes, *e.g.*, the brazing of flanges on to copper pipes	90	10
Ordinary brazing brass	90 to 80	10 to 20
Standard brass	70	30
Muntz metal	60	40

All the so-called special bronzes were in reality 60 copper: 40 zinc brasses to which had been added a small percentage of some other metal. The term "special bronze" was misleading, and he considered "special brass" a more logical term. It seemed that the 1 per cent. or even less, of the "other" metal "stiffened up" the tensile strength without "pulling down" the elongation. Manganese "bronze" was a case in point. The percentage of that metal (manganese) present was often quite low, well below 1 per cent., and sometimes it was absent altogether. The influence of the added manganese was probably purely that of a deoxidiser.

Another important series of alloys was that of the gun-metals. The specification for "Admiralty" gun-metal (special) imposed a minimum of 14 tons per square inch maximum stress and a minimum elongation of 7 per cent. In many cases the figure for maximum stress rose as high as 20 and the elongation as high as 16. The lowest figures he had recorded, in the case of poor samples, were 6 tons per square inch maximum stress and 3 per cent. elongation.

The so-called "mild phosphor-bronzes," were used to a great extent in marine foundries. The average composition was as follows: copper, 90·0 per cent.; tin, 9·5 per cent.; phosphorus, 0·4 per cent. The maximum stress of such an alloy varied from 19 to 26 tons per square inch, and the elongation from 19 per cent. to 50 per cent. This latter figure of 50 per cent. was obtained in the presence of Admiralty officials and constituted a record for this type of alloy. He had conducted a research on the subject and as a result was able to reproduce that figure at any time.

The importance of the pouring temperature and its influence on mechanical properties was next discussed by the speaker, and figures were given bearing upon this point.

The discussion was opened by Dr. Hutton, who said Dr. Longmuir's remarks on moulding sands had greatly interested him, and he agreed that the problem of metal adhering to mould was indeed a difficulty which only extended research could solve.

The Chairman, Professor Desch, said he had been greatly interested in the subject, because his own first practical experience in metallurgy had been in connection with the making of heavy castings for propellers and hydraulic gun mountings. He agreed that the utmost care should be exercised in keeping all the various grades of scrap separate. A knowledge of the purity of metals used in the manufacture of alloys and the influence of the pouring temperature on mechanical properties were two most important items. A certain works on the Clyde produced excellent gunmetal castings, giving good maximum stress and elongation figures. This was because (1) they paid great attention to pouring temperature; (2) they chose their virgin metals carefully, and (3) what scrap they used was their own, which had been kept carefully classified. The subject of fluidity was an extremely important one, and although a great deal of research work had been done on that subject it was not generally known. The degree of superheat above the normal pouring temperature was a factor in fluidity.

A question was here asked as to whether the lecturer could recommend a pyrometer which could be used with ease in the casting shop. A large number of pyrometers were on the market, but there was a real need of some simple device which could be plunged in each crucible as it emerged from the furnace and thus enable the melter quickly to determine the temperature of the melt.

Mr. J. F. Kayser, who spoke next, said that he could have wished that Dr. Longmuir had spent less time in stating how little was known on such subjects as moulding sands and given the meeting the full benefit of that which was known. He agreed that fluidity was a puzzle; it did not entirely depend on the degree of superheat above the pouring temperature, nor did it depend on the distance between the solidus and the liquidus. There were no reliable fluidity tests, the only one being that devised by the American metallurgist Keep. With regard to melting-shop pyrometers, he would like to say that Dr. Richards and he had devised a pyrometer involving a platinum and platinum-rhodium thermo-couple, which was comparatively cheap and easy to use. They had so far been unable to persuade any scientific instrument maker in the country to take their idea up, but it could be easily made in a laboratory. He would, further, like to ask why non-ferrous melters, in general, were so adverse to the use of flux in melting.

Mr. E. A. Smith said he was glad to hear the lecturer allude to (1) the importance of research, and (2) the importance of analysing virgin metals before use. The purity required of virgin metals depended, naturally, on the type of alloy desired. The sample of commercial ingot zinc of which the analysis was given was comparatively pure. Commercial zinc frequently contained as much as 1 per cent. lead.

Captain F. Orme, asked a question with regard to melting losses in brasses due to volatilisation of zinc. The allowance made in the trade for loss of zinc was 2 per cent. of the bulk, not 2 per cent. of zinc content. By careful melting that could be reduced to 1 per cent., and even, 0·5 per cent.; he, therefore, asked Dr. Longmuir what allowance he usually made for loss by volatilisation. With regard to gun-metals and their mechanical properties, the addition of 1 per cent. of nickel had an excellent effect. An alloy, made locally, had recently come to his notice and had the composition:—copper, 89 per cent.; tin, 10 per cent.; nickel, 1 per cent.; this gave a maximum stress figure of 25 tons per square inch and 21 per cent. to 22 per cent. elongation. A small percentage of nickel had a remarkably good effect on the so-called plastic bronzes containing a high proportion of lead.

Dr. Longmuir in replying to the discussion said he was glad to hear the remarks confirming the importance of keeping different kinds of scrap separate. It paid to adopt that course with regard to foundry and machine shop scrap. He agreed that superheat was a necessary factor in fluidity. There were undoubtedly many good pyrometers on the market, but he felt he could not very well give names at such a meeting. With regard to fluidity he, himself, used only crude foundry tests. He was aware of Keep's test. In answer to Captain Orme, he said that 2 per cent. of the bulk (not 2 per cent. of the zinc) was the allowance usually made in the trade for melting losses due to volatilisation. The zinc loss varied greatly; it was sometimes much more and sometimes less, according to the procedure adopted, and he was afraid no hard and fast rule could be laid down.

The addition of a small percentage of nickel to gun-metal interested him very much, and it was only one other instance of what he had already mentioned in his address, viz., that the addition of 1 per cent. of some foreign metal to an "ordinary" alloy greatly improved the mechanical properties. The chief reason, he thought, why brass founders fought shy of fluxes was because they were continually being inundated with patent compositions which claimed to cure every ill. He never used a flux; the only foreign body permitted by him was charcoal, and he was quite satisfied with it.

The meeting terminated with a vote of thanks to Dr. Longmuir for his lecture.

The Optical Society.—At a meeting of the Optical Society, held at the Imperial College, Kensington, on Thursday, the 12th inst., Professor F. J. Cheshire, vice-president in the chair, the following papers were read and discussed: (1) "A Physical Study of Coma," by Mr. L. C. Martin, D.Sc. A specially-designed microscope objective and mounting, calculated to exhibit coma in the absence of spherical aberration and astigmatism, are described. Photographs of a star image, taken when the amount of coma is equavalent to that for which the light distribution has been calculated by the author, are found to verify the numerical work. The photometric examination of the photographic image is carried out by a special method. (2) "Comparison of the Structure of Sand-Blasted and Ground Glass Surfaces," by Mr. F .W. Preston, B.Sc. Glass surfaces smoothed or "greyed" by loose abrasives in the usual way are compared with those produced by sand blasting. The surfaces are so similar when produced by the two methods that they are practically indistinguishable either by the naked eye or the microscope, and the development of the structure by etching shows that the resemblance is not merely superficial but that the structure is in fact virtually identical. Thus, it appears that mere pounding of a glass plate can, and does, produce a surface which is structurally indistinguishable from a smoothed surface of a technical order. Messrs. Adam Hilger, Limited, exhibited a new type of chemical spectrometer, a new model of the Bunsen-Kirchhoff spectrometer for flame spectra, a student's model of the wave-length spectrometer (constant deviation type) and an interference accessory for testing microscope stands and fine adjustments.

INDUSTRIAL NOTES.

In the course of a recent statement, Mr. F. Hodges, secretary of the Miners' Federation, cited figures for miners' wages per shift in October, 1921, and in the present month. The following are some of his extreme figures:—Colliers in Derbyshire, 19*s.* 2*d.*, as against the present-day wage of 11*s.* 1*d.*, a reduction of 8*s.* 1*d.*, or 42 per cent.; colliers in nine other districts have also suffered a reduction of 42 per cent., whilst wages in Somerset, which were 12*s.* 3*d.*, are now 7*s.*, a reduction of 5*s.* 3*d.*, or 43 per cent. Reductions in the remaining districts are of the order of 39 per cent., 38 per cent., 32 per cent., 27 per cent. He also reviewed the wages of labourers, which show reductions of the same order. The owners refute these figures, and state that the subsistence wage, which the independent chairmen of the various Coal Boards have awarded as a supplement to the economic wage, is wholly excluded and ignored, although this addition affects one-tenth of the mining community, the lower-paid workmen. As an instance, the owners quote South Wales and Monmouth, for which 9*s.* 7*d.* per shift is given, but the average wage of coal-getters is 14*s.* per shift, or about £4 per week (5·78 days of 7 hours). In Durham the miner lives rent free, or receives 10*s.* a shift as a rent allowance. Free coal, where given, is equivalent to perhaps 6*s.* per shift. The wages bill from January to June, 1922, was 65,367,526*l.*, or on a basis of 130,735,000*l.* per annum. This showed an increase of 43·7 per cent. over the 1913 wages bill of 91,000,000*l.* This increase of 43·7 per cent. was for a working day one hour less than was worked in 1913; if an eight-hour day basis were substituted, the earnings would be 72 per cent. over 1913, an increase approximately equal to that in the cost of living. The reduction in hours had increased the ratio of unskilled workers to coal-getters, and the revenue of the industry had to be divided amongst a larger number of persons having regard to the output, with the inevitable result that there was less money for each. Mr. Hodges maintains his own figures and asks that the points be submitted to a competent public authority. At the time of our going to press it was announced that the Prime Minister would receive a deputation of the miners' executive.

It is reported that, as the result of a letter written by the Ebbw Vale Company to the South Wales Miners' Federation, representatives of the company met a few days ago representatives of the workmen, for the purpose of reopening discussion regarding outstanding differences. It is further reported that, at the close of the conference, Mr. Vernon Hartshorn said the decision of the company was that, before work could be resumed, a settlement of all outstanding matters must be effected. "Under those circumstances it was useless to continue the discussion." Nothing has transpired as to what points were gone into at the meeting in question; at all events, the conclusion arrived at appears rather a strange one. Had complete agreement been reached, one could understand the futility of continuing discussions; but in the case of the present dispute, which is most involved and entails suffering to outsiders also—local tradesmen amongst many others—the more discussion there was and the sooner it was held would appear to be the right course. Later statements indicate that the situation at Ebbw Vale has been eased to some extent, owing to arrangements having been made by the Ministry of Mines for holding a joint conference on the points in dispute.

A meeting of the Executive Council of the National Union of Railwaymen was held last Friday, to receive a report of the men's negotiating committee on the proposed modifications of the National Agreement by the railway companies. In this connection it is stated that about 750,000 railway employees, from locomotive men to booking clerks, are faced with the prospect of a reduction of 10*s.* per week. At the close of the meeting, Mr. C. T. Cramp, the industrial secretary of the National Union of Railwaymen, said that the proposals submitted by the companies did not affect the standard week's wages, but, if put into effect, they would mean about 10*s.* a week reduction in the gross earnings of the men. Among other proposals, he added, was one dealing with night work, also one on the method of working the 48-hour week, and one or two proposals which especially affected the locomotive men. All these proposals were, of course, open to discussion, and no conclusion could be arrived at until the matter had been exhaustively discussed by the Executive Council of the National Union of Railwaymen. It was probable that the negotiations might extend over several weeks.

The Birmingham journals report that the Brassfounders Employers Association and the Metal Mechanics Society have entered into an agreement, which came into effect last Monday, on the question of a reduction in the war bonus. The employers' original proposal was for a reduction of 16*s.* per week, as from the 1st inst.; following upon negotiations, the reduction agreed upon is to be at the rate of 7*s.* 10*d.* as from last Monday, the 16th inst. The measure was accepted by the men after considerable opposition. This reduction is based, and others in future are to be based, upon the cost of living rate.

Speaking last Monday at York on "The Way to Industrial Peace," Mr. B. Seebohm Rowntree said the engineering employers were losing "hand over fist." There was recently a small contract of 3,000*l.* or so to let at York Cocoa Works, and they were badgered for the order by the biggest firms, with millions of capital, each anxious to capture the order, and each considering, not what profit they could make, but what proportion of loss they could afford. He believed that 20 per cent. more work might be done by the day worker without injury to himself. Improvement under the wages head must come on the lines of increased efficiency. As to hours, the danger now was not that the hours in England were too high, but too low. Forty-eight hours were a reasonable amount, and he gravely doubted the wisdom of a 44-hour week for the mechanic and 39 hours for the clerk. If the choice lay between a lower wage or a longer week, he thought it would be better to have the longer week. As to security and unemployment, there was no more pauperism about insurance for unemployment than for fire, and the 5 per cent. of the wages bill required in normal times to effect it could be provided jointly by the employer, the worker and the State. We must definitely expect as a part of our industrial organisation in the future a comprehensive system of unemployment insurance. The status of the worker must be altered from that of a servant to that of co-operator; the worker must have a definite share in the prosperity of the industry. He had been opposed to profit-sharing because he believed it to be illogical; still, he thought it the right thing to do, and that the balance of advantage was in its favour. The employer of the future must be a leader of his men and not merely an employer, and, if the men would not follow, then they must go, because they could have no place in a team which should pull together, and the industry of the future would have to be a team undertaking.

The issue of the 17th inst. of the *Daily Herald* stated that the decision of the Minister of Pensions to cease responsibility for the maintenance of 700 ex-Service men in lunatic asylums has filled every fair-minded man and woman with indignation, " . . . this callous disregard of the nation's elementary obligation towards the most pitiful of the Great War's disablement cases is surely the worst." The journal adds that nothing so clearly indicates the slump in idealism as this treatment of many of our soldier heroes and their dependents. The article is signed by Mr. A. Henderson, M.P. Has Mr. Henderson ascertained whether some of these ex-Service men may not have lost their reason as a result of the action taken by various trade unions in preventing them from working at a number of callings upon their demobilisation? It is, at all events, certain there are many ex-Service men, many "of our soldier heroes and their dependents," who are greatly suffering in other ways at the present time owing to the lack of "idealism" on the part of trade unions.

A small book by Mr. A. J. Sargent, Professor of Commerce, London University, on "Coal in International Trade," has recently been issued at the price of 2*s.* 6*d.* by Messrs. P. S. King and Son, Limited, Orchard House, Westminster. It states, in the particular instance of coal, that labour is the largest factor in the price, and labour-cost is a question of wages in relation to efficiency. Just before the war Great Britain employed well over a million people in and about the mines to raise its coal; the United States about three-quarters of a million, and Germany somewhat less than seven hundred thousand. The output per person employed was nearly 680 tons in a working year in the United States, but only some 260 tons in Great Britain, and about 270 in Germany. The American output rose steadily from an average of 400 tons in the period 1886–1890, whilst that of Great Britain fell from somewhat over 310 tons per person. The relative efficiency of the miner, the number of effective working days in the year, the number of hours per day, the amount of machinery employed, the thickness and uniformity of the seams, and other physical and geological factors, all have a bearing on the quantity raised. This quantity is closely related to wages and to market prices. The amount to be realised by the sale of 680 tons, as compared with 260 tons, evidently provides a very wide margin available for distribution between the capitalist and the wage-earner. The world of commerce starts with the pitmouth price of coal as the basis of its operations; it is not concerned directly with the relative remuneration of the miner and capitalist—it will not, and cannot, pay more than the competitive market price; it reeks as little of legislatures as of trade unions, and refuses, in the long run, to buy in other than the cheapest market.

The annual report for the year ending December, 1921, recently issued by the Department of Mines and Industries of the Union of South Africa states that there were employed in 162 gold-mining and gold-working concerns 21,607 whites, 206 Asiatics and 181,117 natives, a total of 202,930, or 72·8 per cent. of all labour in mines. Labour employed in diamond mines and prospecting concerns consisted of 6,661 whites, 20 asiatics and 20,595 natives, a total of 27,276, equal to 9·8 per cent. In 79 coal mining concerns there were 2,133 whites, 2,601 asiatics, and 35,177 natives, a total of 39,911, or 14·3 per cent. There were 60 base mining mineral concerns, employing 462 whites and 5,519 natives, a total of 5,981 or 2·2 per cent. Power supply companies and quarries numbered 43 and employed 761 whites, 31 asiatics and 1,838 natives, a total of 2,630, or 0·9 per cent. The total labour, all included, numbered 278,728, against 309,118 in 1920, equal to a decrease for 1921 of 30,390.

BARCELONA INTERNATIONAL EXHIBITIONS.—We are asked to state that two international exhibitions at Barcelona are in course of preparation. One, of furniture and house decoration, is to be held from May to June, 1923, and is to comprise three sections and to include machinery and the technics of the industry. The second exhibition, to be held from October to December, 1923, is to cover Building Technics and is to be divided into 12 sections dealing with the materials used, their testing, the machinery for their preparation, drainage, lighting, heating, ventilation, &c. Both the exhibitions are to take place in existing buildings, the Palace of Modern Art and the Palace of Industry. The second exhibition will be combined with a congress. The offices of the Exhibition Committee are 2, Calle de Lerida, Barcelona.

BRITISH NON-FERROUS METALS RESEARCH ASSOCIATION.—This association, whose address is Athenæum Chambers, 71, Temple-row, Birmingham, has recently issued a pamphlet giving an indication of the research work now in progress. The investigations already started deal with the effect of impurities up to 1 per cent. on the properties of copper; the surface and internal soundness of brass ingots; the jointing of metals, including brazing, soldering and welding; atmospheric corrosion and tarnishing of brass; the determination of alumina and its influence on aluminium and its alloys, &c. The support given to the association by the leading firms seems to be most encouraging, but the field covered is very wide, and many researches, such as those on the improvement of brass, on metal polishing and on soldering, should attract the attention and support of many sections of industry. The pamphlet gives some indication of future work which the council hopes to take up when additional financial support is forthcoming; this future work would include problems of importance to the electrical industries, to die casters and to the tinplate trade.

THE PERMEABILITY OF CONCRETE.—In 1920 the Swiss Hydraulic Association appointed a commission to inquire into simple ways of reducing the permeability of concrete as used in the construction of conduits, canals, quays, &c. Loam was thought of in the first instance. An experimental station was erected, near Zürich, under the direction of a Zürich engineer, Mr. J. M. Lüschinger, and this commission has recently issued its first report, according to *Schweizerische Bauzeitung*. It is found that only highly-plastic loams of very fine grain can be recommended for making the concrete or gravel used in lining canal bottoms and walls impermeable, and is in any case only likely to form a strong protective coating on surfaces which are always under water; layers which are exposed to the action of the sun rays, rain and frost are apt to develop cracks. Rammed loam, even when mixed with sand or gravel, will crack in drying, and cannot be much improved by subsequent wetting. But loose gravel, suitably treated with loam water in such a way that the loam particles settle first in the lower gravel layers, will harden to a stony mass, not liable to cracking. In testing the permeability of the concretes the commission used a novel hydraulic device, made by the L. von Roll Iron Works. This is a cylinder, 20 in. high, nearly 30 in. internal diameter, provided with a domed cover and a cupped bottom and, further, with a perforated false flat bottom. A slightly conical concrete block or disc, about 9 in. thick, rests on the false bottom, the wedge-shaped space between the cylindrical shell and the side of the block being filled in with a tarry pitch. Water is forced under pressure into the cylindrical space between the top cover and the block. The permeability curves, obtained with the aid of this apparatus, are of considerable interest. The amount of water percolating per day through ordinary concrete under a pressure of 5 atmospheres was found to diminish gradually; the fact was not unknown, of course, but quantitative experiments have seldom been made.

4-FT. 6-IN. RADIAL DRILLING AND TAPPING MACHINE.

CONSTRUCTED BY MESSRS. KITCHEN AND WADE, ENGINEERS, HALIFAX.

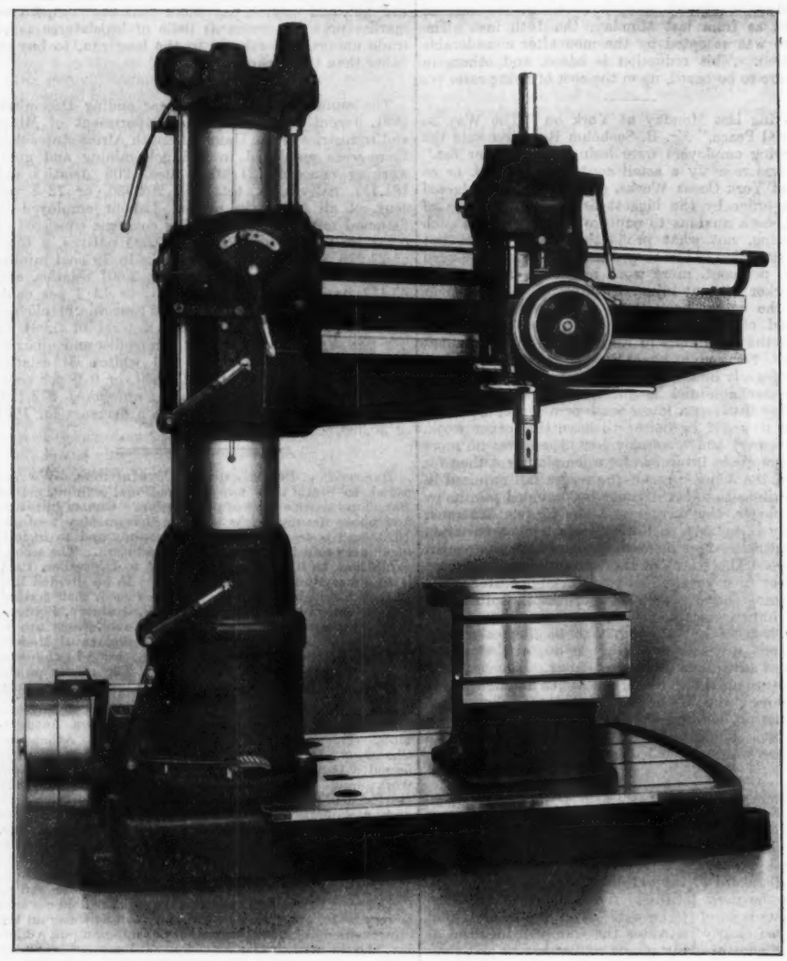


Fig. 1.

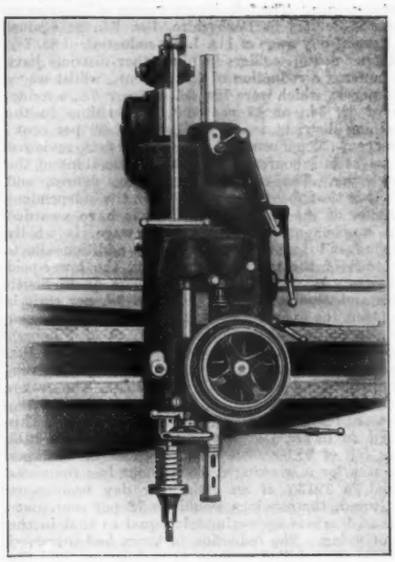


Fig. 2.

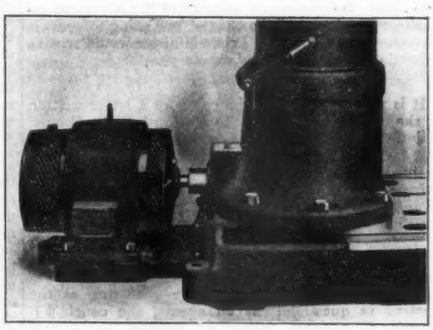


Fig. 3.

The accompanying illustrations show a pattern of radial drilling, boring, tapping and studding machine built by Messrs. Kitchen and Wade, of Halifax. The machine illustrated is the 4 ft. 6 in. size. A 3 ft. 9 in. machine is also constructed, while both are designed either with baseplates or with box beds, an example of the former being given in Fig. 1. The actual maximum radius of the spindle in this machine is 4 ft. 7 in., while the length of traverse on the arm is 3 ft. 4 in. The maximum height of the spindle to the baseplate is 4 ft. 7 in., and the minimum 1 ft. 7 in. The arm can be adjusted vertically through a height of 2 ft. 0¾ in. The baseplate has a working surface 4 ft. 2 in. in length and 3 ft. wide, and the floor space occupied by the belt-driven machine is 7 ft. by 3 ft. In this machine the belt pulleys are 14 in. in diameter and are designed to run at 480 r.p.m. The drive is transmitted to a vertical shaft inside the column, and then through gearing down to the grease-tight gear box on the front of the arm at the pillar. This box gives four speeds, which, with back gear on the saddle, give altogether eight spindle speeds ranging from 500 r.p.m. to 30 r.p.m. The gear-box speed changes are obtained by means of one lever fitted with stops, and an indicator plate gives the correct speed and feed for all holes within the range of the machine.

The spindle is spring-balanced. It is provided with ball-thrust bearing and runs in a hard steel quill cut with a rack with which the feed pinion meshes. The least diameter of the spindle is 1⅝ in., and the length of feed 11 in. The self-acting feed is provided with three changes, which can be thrown in without stopping the machine. The self-acting feed drive is by means of worm and worm wheel. It can be instantly engaged or thrown out. Fine hand adjustment or feed is obtained by means of the hand wheel in front of the saddle. A positive clutch on the saddle enables the spindle to be started. stopped or reversed. Backing out after tapping is accomplished at a speed of 4 : 1 by throwing in a single gear. The saddle is traversed by hand by means of rack and pinion. All mechanism on the saddle is enclosed.

The arm is raised and lowered by power by a vertical screw driven from the gear casing at the top of the pillar, the load being taken on a heavy type ball thrust bearing. Stops are provided to prevent over-running. The sleeve is long and the pillar extends inside it to the top. The sleeve is carried by ball bearings, and the radiusing requires very little effort. A lever at its lower end serves to lock the sleeve in position. When required the machine is supplied with the tapping spindle shown in Fig. 2, running one-third of the speed of the drilling spindle. Both right and left-hand threads can be tapped with this arrangement, which is furnished with a quick backing-out motion.

The machine illustrated in Fig. 1 is belt-driven. When required to be electrically driven the motor is arranged as shown in Fig. 3, and the reduction gearing is placed inside the column. The motor furnished is of 5 h.p. to 6 h.p., running at a speed of about 1,000 r.p.m. The capacity of the machine is said to be up to 2½ in. holes for cast iron and 2 in. for steel, while as regards tapping the machine can handle 1¼ in. Whitworth or 2¼ in. gas threads. It can be employed for boring up to 8 in. in diameter, and it is being also successfully used for trepanning up to 13 in. diameter holes.

HIGH-CAPACITY RAILWAY SCREW COUPLINGS.

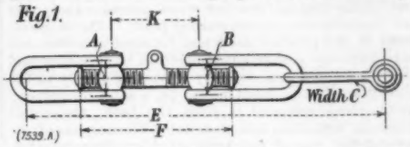
The comparatively small number of accidents arising from coupling failures, which, on account of their gravity, come to the knowledge of the public is no real criterion of the coupling question. The three-link and screw railway couplings are limited in their capacity by the practical consideration that they must be capable of being easily handled. In some connections this has restricted the loading of trains so that it has not been possible to take full advantage of a gauge. In this country as loads have increased, coupling failures have become more serious, although the situation has secured the consideration of railway engineers for many years. In 1921 there were recorded on the railways of this country, no less than 8,876 cases of trains dividing. Of these coupling failures 2,522 related to passenger trains, and 6,354 were accidents to goods trains. It speaks well for the care with which our railway service is conducted, that the serious results from all these failures were so small.

The standard material formerly employed for couplings was Yorkshire iron. When additional strength was sought by an increase of section, and the limiting weight was reached, attention turned to the use of high tensile steels. Many years ago we published excellent results obtained with couplings of nickel-chrome steel which provided greater strength for less weight. We do not know what proportion of these are now in use, but it is evident from the figures we have given the problem is far from solved. From discussions before the Iron and Steel Institute, &c., the liability of nickel-chrome steel to temper-brittleness would seem to preclude this material from furnishing the final solution, and in this connection it is interesting to note that couplings are now being manufactured of "Vibrac" steel introduced by Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited, which is said to be free from temper-brittleness. The steel is already in use for marine and automobile work and has given satisfactory results.

Couplings of this steel have recently been submitted

to tests at the National Physical Laboratory, at Lloyd's Testing House, Wallsend, and at the Sheffield Testing Works, and we are enabled to give some of the results obtained, which speak for themselves. The first two illustrations, Figs. 1 and 2, relate to Izod impact tests made at the National Physical Laboratory. The figures below Fig. 1 show the deformation of the coupling under the test. The coupling shackle normal section was 1¼ in. diameter, and the weight of the coupling without lever was 59·2 lb., and complete with lever 70·1 lb. The couplings were subjected to the condition of the shackle after eight blows, when one shackle was still quite free though the other worked tight, and the screw was slightly bent. The ordinary

Fig. 1.



No. of Blow.	Measurement in In.						Striking Energy.	Energy Absorbed.
	A.	B.	C.	K.	E.	F.		
							ft.-tons	ft.-tons.
Initial Measurement	3·94	3·93	3·94	13·50	39·33	18·48	—	—
1	3·90	3·84	3·66	13·52	39·69	18·48	5·0	2·2
2	3·90	3·81	3·59	13·55	39·90	18·48	5·0	1·9
3	3·89	3·80	3·53	13·55	40·06	18·48	5·0	1·9
4	—	—	—	—	—	—	5·0	1·7
5	—	—	—	—	—	—	5·0	1·5
6	3·91	3·77	3·44	13·56	40·32	18·54	5·0	1·5
7	—	—	—	—	40·30	18·57	5·0	1·6
8	3·94	3·77	3·41	13·63	40·45	18·59	5·0	1·7
Total extension	Nil	−0·16	−0·53	+0·13	+1·12	+0·11*	Total	14·0

* After six 5 ft.-ton blows coupling not visibly affected. After eight blows, screw slightly bent. One shackle quite free. Others worked tight.

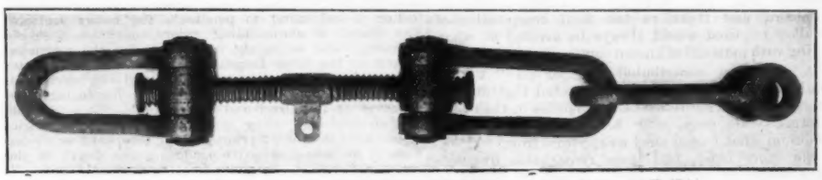
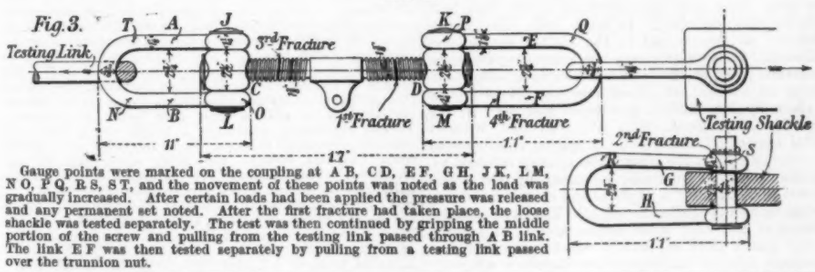


FIG. 2.



Gauge points were marked on the coupling at A B, C D, E F, G H, J K, L M, N O, P Q, R S, S T, and the movement of these points was noted as the load was gradually increased. After certain loads had been applied the pressure was released and any permanent set noted. After the first fracture had taken place, the loose shackle was tested separately. The test was then continued by gripping the middle portion of the screw and pulling from the testing link passed through A B link. The link E F was then tested separately by pulling from a testing link passed over the trunnion nut.

Position of Gauge Points.	—	Movement and Set, in In. Load in Tons. 1	18	30	35	40	50	60	70	80	85	Position of Fracture.	Maximum Load. Tons.	Tons per Sq. In. at Bottom of Thread.	Appearance of Fracture.
in.															
A B = 4	Closing in	zero	none	0·02	0·05	0·08	0·10	0·12	0·16	0·20	0·25	(1)			
	Set	—	—	—	—	—	none	0·02	0·08	0·14	0·18				
C D = 12	Extension	zero	—	—	—	none	0·02	0·02	0·03	0·03	0·04	Screw ..	111·80	75·3	Fibrous.
	Set	—	—	—	—	—	—	—	—	—	none				
E F = 4	Closing in	zero	none	0·03	0·05	0·08	0·09	0·10	0·11	0·18	0·20				
	Set	—	—	—	—	—	—	none	0·02	0·08	0·11				
G H = 4	Closing in	zero	0·02	0·04	0·07	0·09	0·10	0·14	0·20	0·29	0·34	(2)			
	Set	—	—	—	—	—	none	0·04	0·10	0·19	0·25				
J K = 15	Opening out	zero	0·02	0·04	0·05	0·05	0·06	0·08	0·10	0·11	0·13	Sheared the pin of the loose shackle G H	145·00	—	Silky.
	Set	—	—	—	—	—	none	0·02	0·02	0·02	0·03				
L M = 15	Opening out	zero	0·02	0·03	0·04	0·05	0·05	0·06	0·08	0·10	0·10				
	Set	—	—	—	—	—	—	—	—	—	none				
N O = 8	Extension	zero	—	—	—	none	0·02	0·02	0·03	0·07	0·09	(3)			
	Set	—	—	—	—	—	—	—	none	0·03	0·05				
P Q = 10	Extension	zero	none	none	0·02	0·02	0·02	0·02	0·02	0·03	0·06	Screw ..	113·70	76·6	Fibrous.
	Set	—	—	—	—	—	—	—	—	none	0·03				
R S = 10	Extension	zero	—	—	—	—	none	0·02	0·03	0·05	0·08				
	Set	—	—	—	—	—	—	—	—	0·02	0·05				
S T = 42	Extension	zero	0·09	0·12	0·15	0·16	0·18	0·24	0·32	0·40	0·49	(4)			
	Set	—	—	—	—	—	—	none	0·07	0·15	0·26	Link E F ..	142·50	—	Fibrous with a silky edge

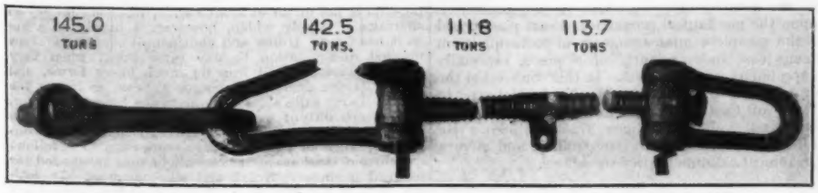


FIG. 4.

a number of blows, the striking energy being 5 ft.-tons. The effect is shown in the table. After five blows the coupling was not visibly affected. Fig. 2 shows coupling is usually rendered unserviceable by three blows in such a test.

The static load results are shown in Figs. 3 and 4 and the table accompanying Fig. 3. It may be mentioned that a heavy Yorkshire iron coupling of 1¼ in. shackle section will stand as a rule a static of between 43 tons to 50 tons. It will be noted from the table of tests at the Sheffield Testing Works that the maximum loads taken before fracture were in the case of the Vibrac coupling all over 110 tons with a shackle section of 1¼ in., while permanent deformation of even the smallest amount was not discernible until a load well exceeding the strength of a Yorkshire iron coupled had been attained. After the screw had failed the remaining parts were tested to obtain the resistance to fracture of the shackles. Although the screw failed first at 113 tons it was still possible to move the shackles on the trunnions.

All detail parts of the couplings were treated alike before assembling, and the usual mechanical and physical tests gave the following results:—

Yield-point	62 tons per sq. in.
Tensile strength	68 tons per sq. in.
Elongation	19·5 per cent.
Reduction of area	59·0 per cent.
Impact	54 ft.-lb.

In view of the shackle withstanding a load of 142 tons, it would appear that the screw might well be treated to withstand about 130 tons without impairing its high resistance to shock stresses.

We understand that Messrs. Sir W. G. Armstrong, Whitworth and Co., have obtained contracts for couplings of this character, in addition to other uses for this steel which, as noted above, include its application to automobile and marine work, as well as aero engine and turbine and locomotive details, &c.

FRENCH FOUNDRY CONGRESS.

THE Association Technique de Fonderie de France held its second congress at Nancy from the 5th to the 8th inst., when a number of papers were read and discussed. The first congress was held in Paris in 1913; the war put a stop for a time to further meetings.

The first paper on the list of the Nancy Congress was contributed by Mr. C. Kluytmans, and one of its opening statements was to the effect that in foundry work foreign countries had recourse to science in actual practice to a greater extent than was the case in France. He extended an appeal to all French foundries, asking them to give every consideration to laboratory researches, and to work in close collaboration with the metallurgists, since these were intimately acquainted with all reactions, combinations, chemical and physical laws governing metals. He advocated in foundry practice a more complete understanding between patternmakers, moulders and metallurgists. His paper contained for the guidance of foundrymen a series of recommendations, dealing first with the fan, the part of a foundry plant which he placed to the very front. When the laying down of a foundry was decided upon, he said, the first and only considerations which seemed to be given attention to were the output in castings aimed at and the dimensions to be given the cupola for that output; the fan and the volume of air to be supplied for burning the coke were second or even only third-rate considerations. This, he added, was a very unsatisfactory method of proceeding, since it led to high consumption figures and to defective castings. He, personally, dealt with a new plant in the following order: (1) The output; (2) the fan; (3) the coke; and (4) the cupola. The output required of the plant was a primary condition in order to arrive at the volume of air to be supplied to the cupola for burning a maximum quantity of coke (relatively to the air) to melt the maximum quantity of pig-iron in a given time. The dimensions of the cupola could then be determined on the basis of the three factors: pig-iron, volume of air, and weight of coke, but the volume of air was the controlling agent in foundry practice. Since, for supplying one volume of oxygen in the cupola it was necessary, as was well known, to deliver 4·347 volumes of air, the quantity of coke which could be burnt for a given fan delivery was easy to arrive at. The paper then dealt with the volume of air required for two classes of coke, one better than the other, of which he gave the analyses. The best place for locating the fan was as close as possible to the cupola. In regard to the dimensions of the tuyeres, opinions varied; some metallurgists advocated one-tenth the area at the largest cupola diameter, others one-seventh, whilst British metallurgists gave them one-fifth that area. This was a difficult problem in cupola construction. The author found the latter ratio the most suitable one. He advocated keeping the air pressure and volume under constant control by the use of recording gauges which can be read at any moment and by anyone. The height generally adopted for the cupola was four times the diameter; a minimum of five times the diameter was preferable, as allowing the burning of the CO, hence heat recuperation. Notwithstanding the cupola dimensions, however, defects proceeding from bad working applied both

to higher and to lower cupolas. After dealing with the formation of the charges, the author stated that when tapping gave a comparatively cold and slowly flowing cast-iron, this was due to a too heavy pig-iron charge relatively to the coke, or, if the pig-iron were in the right proportion, to too large pigs. When the pig-iron charge was too heavy, the remedy lay in decreasing it, not in increasing the coke charge, for the fan was designed to deliver a volume of air for a given coke charge; the weight of coke could not be increased without increasing at the same time the volume of air, and this remedy would be worse than the evil. In making up the charges, the author advocated, both for the pig-iron and the coke, having the large pieces in the centre of the cupola, and the smaller ones at the sides against the cupola wall. He then gave calculations for determining the weight of the charges in coke, pig-iron and flux. A series of similar cupolas, he added, could not be expected to give the same results as would a series of similar machine tools: in a cupola the nature and the quantity of the elements supplied to it varied, as also did the human factor, and the latter had a very great influence indeed. The casting temperature varied with the type of casting required, and on this point opinions were greatly divided. For example, the casting temperature of rolls had often been discussed, some foundrymen advocating casting hot and others casting comparatively cold, scientific explanations appearing to be right in both cases. The shape of the castings, and the composition of the cast iron here intervened; from instances quoted by the author, the personal factor and the experience of the foundryman also played an important part.

Two papers were contributed by Professor J. Seigle, Nancy School of Mines, one dealing with the "Heat Balances of Cupolas"; this, after analysing the various elements which came into play, stated that much remained to be done from the point of view of the precision of the recordings which were used for the drawing-up of such balances; moreover, a degree of uncertainty would always prevail in regard to them since it was impossible to calculate with sufficient accuracy the heat losses by radiation and conductivity. The second paper by the same author was on the subject of the "Characteristic Mechanical Features of Cast-Iron." In this, Professor Seigle reviewed the main causes which made for the precipitation of graphite, and also the composition of cast-irons for different purposes. Precaution was to be exercised when comparing Brinell test figures with the figures given by bending and tensile tests, since equal tensile figures were given by two different classes of cast-iron which showed, the one a Brinell number ranging between 150 and 160, and the other a Brinell number between 260 and 275. Another quality which gave the best results in tensile, bending and shock tests, had a Brinell number between the above, ranging namely from 180 to 220.

A contribution by Messrs. L. Piedbœuf and M. Remy had reference to "Tests of Malleable Castings." In this, the authors stated that their pig-iron was of a generally regular composition and the grey brand required to be analysed occasionally for silicon only, whilst the white pig-iron, as it contained up to 0·15 per cent. of sulphur, had to be analysed for this impurity. It was necessary also to test occasionally the castings before malleableising for both silicon and sulphur. In the matter of physical tests of malleable castings, the authors advocated their standardisation, and in this connection they called attention to the series of questions put before German manufacturers by the committee formed for the inspection of such material. A problem which required investigation had reference to the occurrence of black patches in the castings, in which patches, called "shrinks" in the United States, Mr. Touceda, the American scientist, had found free cementite. To reduce these defects, Mr. Touceda advocated using heavy runners or discards and greater regularity in the thicknesses of the castings. An expert, Mr. Leonard, speaking at the recent Liége Congress, traced the formation of these defects to gases from the mould; it would seem that at certain parts of the latter, local explosions occurred, causing gases to penetrate the metal which was not completely solidified at the time, the gases diffusing and producing the patches in question. Mr. Kluytmans, on the other hand, found these to be pearlite deposits, formed at parts where one section of a piece joined another section, and that their formation was influenced by the direction in which the liquid metal flowed. The characteristic features of malleable castings, according to the author, required to be advertised more extensively than they now were, and among these features were the possibility of manufacturing thin pieces which could be machined easily and rapidly, the excellent appearance of the material, and its high resistance to vibrations and to repeated shocks.

In a paper on "Small, Side-Blown Converters," by Mr. Levoz, the author entered a plea for his converter of this type, as the forerunner of all such converters.

A communication by Mr. Brasseur on "The Electric Furnace in the Bronze Foundry," stated that the most marked tendency at the present time in copper, brass and bronze foundry practice was to increase the power and heat efficiency of the melting plant. The improvement in the product itself had followed at a distance only the very real progress made in the construction of furnaces, refining generally consisting simply in the absorption of the burnt metal by a solid deoxidising agent which removed it from the bath, the result being an important loss of metal. This explained the present-day use of the antiquated graphite crucible, notwithstanding its deplorable heat efficiency, every time that the obtaining of a good quality product was of more importance than the saving to be derived from the use of a different means of melting. When melting took place in a reverberatory furnace, oxidising of the metal occurred. This disadvantage was lessened by melting in electric arc furnaces, but the arc might volatilise certain metallic constituents of an alloy and change its final analysis; the actual quality of the metal could only be ascertained after solidification, and no ultimate treatment could correct "a bad bronze." The author then dealt with the melting operation in detail, and advocated the induction electric furnace, which was completely closed in, and in which "the helicoidal action of the particles of the metallic bath resulted in a most effective stirring." The castings made of metal melted in the induction furnace had a remarkable homogeneity. Loss by oxidation was "nil," that by volatilisation was insignificant, and therefore the final composition of the alloy required would always be arrived at when starting with material of known composition.

Mr. de Fleury contributed a paper on "A New Aluminium Alloy, 'Alpax.'" He stated that duralumin, an alloy having remarkable qualities in the rolled or forged state only, after heat treatment, was to aluminium what forged steel was to mild iron. Alpax, on the other hand, had these remarkable qualities in the shape of castings only. Alpax, in regard to aluminium, was comparable to cast steel as against cast iron. This gave an indication of the vast field open for the new alloy. In truth, this alloy, called "Alpax" in France and in the United States, and "Silumin" in Germany, was not a novelty, from the theoretical point of view; it was simply an alloy containing 13 per cent. of silicon, and was referred to in an *étude* by Mr. Guillet, published last May in the *Revue de Métallurgie*. This alloy as cast without special treatment was fragile; a special treatment in the crucible gave it the remarkable quality referred to. The treatment in question, patented by Dr. Pacz, appears to consist of "a physical and chemical refining process by means of alkaline salts." The characteristic features of the alloy were enumerated; its specific gravity was a third of that of steel; it would find numerous uses in the motor car industry where it would make for decreased weight combined with increased strength. There was also a great future for this alloy in naval construction, since high-power Diesel engines could be built entirely of "Alpax." Aviation also opens out for it numerous possibilities.

A paper by Mr. A. Portevin was on "The Influence of Phosphorus on Brass." The publication of this followed upon questions which had been addressed to him (the author) as to the disadvantages which might result from the presence of phosphorus in cast brass. He had dealt with the matter, although the circumstances in which the information might be of use were quite exceptional circumstances, since there was no motive for adding phosphorus to copper-zinc alloys. Tables in the paper showed that the presence of phosphorus did not materially affect the mechanical properties of the alloy, so long as the phosphorus content remained below 0·05 per cent.; on the other hand, when it exceeded 0·5 per cent. the alloy became fragile whilst its hardness increased. The results of mechanical tests on the series of brasses he experimented upon afforded a further proof—if a further proof were needed—of the fundamental error made in submitting to tensile tests brittle metals or alloys; the discordance in the figures arrived at also showed, among other things, the notable influence which cooling conditions had upon the mechanical properties of cast pieces, and hence the complete unmeaningness of tests made on specimens cast independently of a piece, especially if the specimens were chill cast. In this connection the author recalled the paper by W. N. J. McLean, in the "Art of Casting in High Tensile Brass" (see Engineering, vol. cix., pages 372 and 388). He also referred to the work by Mr. Guillet, and gave a micrographical examination of the alloys.

Seaplanes in Mail Service.—Seaplane mail service at New Orleans will be established soon, says *Commercial America*, Philadelphia. The plane will catch outgoing steamers with late mail and bring in mail from the steamers half a day ahead of time.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Hull Coal Traffic.—A steady expansion in exports in the South Yorkshire area, despite heavy railway charges to the coast, is shown in the official return of traffic receipts for September. The total tonnage dealt with at Hull, 567,493 tons, was 274,879 tons more than in September the previous year. For the nine months the imports total 3,785,415 tons as compared with 1,487,407 tons for the relative period of 1921, an advance of 2,298,008 tons. Whereas in September, 1921, only 81,485 tons were shipped abroad, last month foreign buyers took 406,732 tons. Germany's requirements were very much greater than last year. During September she took 30,069 tons against 3,604 tons in September, 1921, and from January to September last 423,908 tons against 18,151 tons for the corresponding period in 1921. United States purchases show a falling-off, but as against this a substantially increased trade is being maintained with France, Holland and Sweden, and North Russia is again becoming an important factor. The Brodsworth, Bullcroft, Hickleton, Ramcroft and Yorkshire Main group were the largest exporters with 85,774 tons for the month, and 718,510 tons for the nine months. A heavy business was also done by Denaby and Cadeby Main, whose nine months' shipments totalled 425,885 tons including 58,380 tons for September.

Iron and Steel.—That the maintenance of idle plant is proving a severe tax on the best organised concerns is indicated in the disclosure that United Steels, Limited, last year spent more than £300,000 in this connection. Other firms of relative standing have been similarly hit, though this particular item is gradually declining with the freer booking of new business. A more hopeful feeling is beginning to penetrate the heavy sections. The dearth of shipbuilding orders continues a severe handicap, and is mainly responsible for the restricted output of the large forges. On the other hand, better movement is evident in constructional engineering on general account, and this is responsible for an increased turnover at foundries and rolling mills. It is possible to find jobbing rolling mills in the Sheffield district which have run uninterruptedly for the past five weeks. This is no mean record considering the depth of the recent depression. Improvement in steelmaking is still mainly confined to basic and common qualities. Business in acid steel continues very slow. Inquiries are more abundant for tool steels and special steels for engineering construction, but the price factor is still a heavy handicap, especially in those overseas countries where unfavourable exchange rates obtain. Locomotive makers have on their books substantial orders from India, and a fair weight of business is passing in axles, tyres, and wheels, though the gross weight of overseas contracts for railway rolling-stock is still a long way below the average. Textile machinery continues a bright exception in an otherwise irregular market. More inquiries are reported from Colonial sources for files, saws, pincers and hammers. Negotiations are proceeding for further deliveries to Russia on the cash-with-order basis. In raw and semi-finished materials Siemens acid billets are quoted round about 10*l.*, carbon basic billets, 8*l.* 5*s.*; West Coast hematites, 5*l.* 5*s.* to 5*l.* 10*s.*; East Coast hematites, 5*l.* 5*s.* to 5*l.* 10*s.*; Lincolnshire No. 3 foundry, 4*l.* 2*s.* 6*d.* to 4*l.* 5*s.*; Lincolnshire forge, 3*l.* 17*s.* 6*d.* to 4*l.*; Derbyshire No. 3 foundry, 4*l.* 2*s.* 6*d.*; and Derbyshire forge, 3*l.* 17*s.* 6*d.*

South Yorkshire Coal Trade.—Colliery owners have found it impossible to maintain recent advances in house coal. Despite the increase in London retail rates, best branch hand picked have been marked down 3*s.* as compared with a month ago, Barnsley best Silkstone 2*s.* 6*d.*, and Derbyshire best house and best large nuts each 1*s.* Best steams on the other hand are an improved market. Exports to Germany, France, and Holland are all on the upgrade. Best quality slacks are moderately active, but there is weakness in inferior grades, and cobbles and nuts are on the quiet side. Exports are absorbing the surplus of furnace and foundry coke. Quotations: Best branch handpicked, 32*s.* 6*d.* to 34*s.* 6*d*; Barnsley best Silkstone, 28*s.* to 30*s.*; Derbyshire best brights, 24*s.* to 25*s.*; Derbyshire best house, 21*s.* 6*d.* to 22*s.* 6*d.*; Derbyshire best large nuts, 18*s.* 6*d.* to 20*s.* 6*d.*; Derbyshire small nuts, 15*s.* to, 16*s.* 6*d.*; Yorkshire hards, 20*s.* to 21*s.*; Derbyshire hards, 19*s.* to 20*s.* 6*d.*; rough slacks, 8*s.* 6*d.* to 10*s.* 6*d.*; nutty slacks, 8*s.* 6*d.* to 10*s.* 6*d.*; smalls, 3*s.* to 5*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—Business in Cleveland pig-iron is not on an extensive scale, due very largely to shortage of supply which, however, is hardly so acute as it has been. Home and continental customers show marked disinclination to pay rates asked when they can purchase Midland iron on much lower terms, and the American demand at length appears to be on the wane. Large sales already made to the States, however, will absorb output over the next few weeks, and this month's Atlantic shipments are expected to be considerably heavier than for many years past. The following current market quotations might now be shaded for forward business: No. 1 and siliceous iron, 97*s.* 6*d.*; No. 3 G.M.B., 92*s.* 6*d.*; No. 4 foundry, 90*s.*; and No. 4 forge, 85*s.*; all f.o.t. makers' works, and f.o.b. Tees.

Hematite.—Substantial home and export sales of East Coast hematite have greatly changed the statistical situation. Several makers are now unable to offer iron for early delivery, and demand continues on quite a

good scale. With the position thus materially improved, the values are moving steadily upward. Nos. 1, 2 and 3 are 92*s.* 6*d.* to 95*s.*, both for home purposes, and for despatch to foreign destinations, and No. 1 is put at 6*d.* above mixed Nos.

Foreign Ore.—Extreme quietness characterises foreign ore. Consumers are carrying considerable stocks, and imports against sales made some time ago are on quite a good scale, but new business is hardly heard of. Quotations are difficult to fix, but it is reported that an offer to sell best rubio at as low as 22*s.* 9*d* c.i.f. Tees failed to tempt buyers.

Blastfurnace Coke.—Durham blastfurnace coke continues to advance notwithstanding protests of local users that quotations have reached a level which alarmingly handicaps production of pig-iron for the market. Up to 31*s.* has now to be paid for medium qualities delivered.

Manufactured Iron and Steel.—What little change is noticeable in finished iron and steel is for the better, but there is still vast room for improvement. Inquiries are expanding, and in one or two branches a few orders are coming in, but the volume of trade doing is far from heavy. Quotations are well maintained. The following are among the principal market rates: common iron bars, 10*l.* 10*s.*; iron rivets, 11*l.* 10*s.*; steel bars, 9*l.*; steel billets, 7*l.* 10*s.* to 8*l.* 5*s.*, according to quality; steel boiler plates, 12*l.* 10*s.*; steel ship, bridge, and tank plates, 9*l.* to 9*l.* 10*s.*; steel angles, 8*l.* 15*s.*; steel joists, 9*l.* 10*s.*; steel tees, 10*l.*; heavy sections of steel rails, 9*l.*; fish plates, 14*l.* 10*s.*; black sheets, 12*l.*; and galvanised corrugated sheets (24 in. gauge, in bundles), 16*l.* 10*s.*

Steelworks Restarting.—Three furnaces at the Clarence Steelworks of Messrs. Bell Bros., Limited, are being relighted. The works were closed down in August last. Messrs. Bolckow, Vaughan and Co., Limited, expected to partially restart their Eston steelworks early next month. The establishment has been idle for twelve months past, and during that period improvements and extensions on a large scale have been carried out. Hope is entertained that other idle plant will be in operation once more before long.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

State of Trade.—The general trade position throughout the country cannot be said to have shown much change of late, although a better tone certainly prevails. A limited number of textile concerns, in a certain line, are busy, but few other branches of industry are so fortunately placed at the moment. Nevertheless the general conditions are just the turn better, which should shortly tend to some improvement in the engineering and iron and steel trades. The latter are most severely hit by the scarcity of shipbuilding orders, but in shipbuilding circles a better tone prevails, and before many months are past employment in the various yards may show an increase. Several new contracts are reported this week, and inquiries—some of which are expected to lead to early business—are again more numerous. The coal trade is nothing like what it should be at this time of year, and how could it be with so much dull trade, but some fair shipments are being made, and there is quite a respectable amount of household varieties being sold. The reductions now in force in the Scottish railway rates for the undernoted traffics will help materially in the development of trade: Coal, coke and patent fuel for blast furnaces and steel works; traffic in Class A (iron ore, &c.); traffic in Class B (bricks, &c., for blast furnaces and steel works).

Scottish Steel Trade.—Little, if any, change has taken place in the Scottish steel trade over the week, and the outlook is not too bright. There is no pressure for supplies, and orders are of very small bulk, with the result that managements are hard put to it to keep plant running. Such a state is bound to continue so long as the present hand-to-mouth style of buying is the policy found necessary by consumers. Plate mills are moving very slowly, and the demand for structural sections is the turn quieter again. In the black sheet trade there is little change, and even the demand for the lighter gauges has fallen off somewhat. General export trade is quiet. Prices are unaltered over the week.

Malleable Iron Trade.—The state of the malleable iron trade of the West of Scotland continues to be far from satisfactory and the outlook is not very promising. Neither on home or export account is there much business passing and plant is running intermittently. Prices are without change and "crown" bars are quoted at 10*l.* 10*s.* per ton, delivered Glasgow.

Scottish Pig-Iron Trade.—The producers of Scottish pig-iron report a fair amount of activity still, and shipments abroad are very satisfactory. Quite a number of orders have still to be fulfilled for America and active conditions are likely to rule for some time ahead. The demand is almost wholly for foundry grades and hematite is moving but slowly. A firm tone prevails over all. The following are to-day's market quotations:—Hematite, 5*l.* 7*s.* 6*d.* per ton, delivered at the steel works; foundry iron No. 1, 5*l.* 5*s.* per ton, and No. 3, 5*l.* per ton, on trucks at makers' yards.

Institution of Engineers and Shipbuilders in Scotland.—The opening meeting of the Institution of Engineers and Shipbuilders in Scotland for the ensuing session will be held on Tuesday of next week, 24th inst., in the headquarters in Glasgow, when the president, Mr. Harold E. Yarrow, C.B.E., will deliver his address, and Lieutenant-Colonel Sir Alan H. Burgoyne, M.P., will read a paper on "Sea Power or Air Force." The other papers on the syllabus for the session are: "The Treatment of Mild Steel," by Dr. Walter Rosenhain, B.A., F.R.S.; "Radio Telephony," by Professor G. W. O. Howe, D.Sc.; "The Development of the Sulzer-Diesel Engine," by Engineer Lieutenant-Commander J. L. le Mesurier, R.N.; "Some Experiments on an Oil Engine," by Mr. A. I. Nicholson, B.Sc.; "The Beardmore-Tosi Diesel Engine: Test-Bed Results and Sea Trials," by Mr. Robert Love; "Electrical Transmission of Power as Applied to Propelling Machinery," by Mr. W. J. Belsey; "Electrical Appliances on Modern Vessels," by Mr. J. S. Rankin; "Vane Wheels for Ship Propulsion," by Mr. Maurice E. Denny, C.B.E., B.Sc.; "Launching Velocities and Drags," by Professor Percy A. Hillhouse, D.Sc.; "The Application of New Freeboard Regulations," by Mr. A. Chisholm, B.Sc.; "The Longitudinal Strength of Bulk Oil Carrying Vessels," by Mr. T. R. Thomas, B.Sc., and Mr. James Turnbull; "Modern Passenger Liners," by Mr. T. N. S. Dickson; "The Arch Principle of Ship Construction," by Mr. Maxwell Ballard; and "A New Method of Boat Lowering," by Mr. Colin D. McLachlan. Mr. Edward H. Parker, the secretary, deserves to be complimented on the excellent syllabus arranged.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—An analysis of the Customs' returns of the volume and value of the Welsh coal exports in September shows that there is every prospect of the colliery owners for the first time being able to retain their standard profits of 17 per cent. and that possibly the wages of colliery workers will be raised above the minimum. This is due to the fact that the volume of trade in September was the largest for at least ten years past, while the proceeds reached the highest level for the current year. The volume and value of shipments from the principal ports in August and September are shown below:—

	August.		September.	
From	Tons.	£	Tons.	£
Cardiff ...	1,395,516	1,620,788	1,560,602	1,908,509
Newport ...	417,495	484,578	455,157	513,701
Port Talbot	193,425	239,262	193,332	245,238
Swansea ...	248,627	414,760	245,779	434,917
Totals ...	2,255,063	2,759,388	2,454,870	3,102,365

It will be seen that total shipments in September were 200,000 tons in excess of those of August and that the revenue was also 343,000*l.* more. Shipments of large steam coal amounted to 1,537,972 tons of a value of 2,025,409*l.*, or 26*s.* 4*d.* per ton, compared with 25*s.* 1*d.* in August and 26*s.* 4*d.* in January last. Exports of steam smalls totalled 660,750 tons, valued at 609,473*l.*, or 18*s.* 5*d.* per ton, the same as in August but 2*d.* below the May average. Shipments of anthracite large coal amounted to 92,546 tons of a value of 238,249*l.*, or 51*s.* 6*d.* per ton compared with 47*s.* 6*d.* in August, while exports of anthracite smalls totalled 65,156 tons, value at 97,577*l.*, or 29*s.* 11*d.* per ton, against 30*s.* 1*d.* in August.

Iron and Steel Trades.—A scheme for the regulation of tin plate prices was agreed at a meeting of the Welsh tin-plate makers and Siemen's steel makers held at Swansea on Monday. It was decided to fix a minimum price of 19*s.* 3*d.* for standard boxes of tin plates, while the Siemens steel makers agreed to reduce the price of steel bars from 7*l.* 7*s.* 6*d.* to 7*l.* per ton. Ninety-five per cent. of the tin-plate makers have agreed to the proposals which it is hoped will stimulate trade and prevent stoppages. Exports of iron and steel goods last week amounted to 9,249 tons, compared with 5,456 tons, 2,205 bundles, 420 packets, 215 boxes and 46 cases in the previous week. Last week's shipments consisted of 2,192 tons of black plates, 4,985 tons of tin plates, 2,072 tons of galvanised sheets and 4,802 tons of iron and steel.

TEXTILE MACHINERY EXHIBITION: ERRATUM.—In our account of this exhibition, on page 430 *ante*, we stated inadvertently that Ferodo brake linings, &c., were shown at the stand of Messrs. G. Stibbe and Co., Limited, Leicester. As a matter of fact, Messrs. Stibbe's exhibit was confined to their textile machinery for underwear, necktties, hose, &c., and the Ferodo products were exhibited independently by Messrs. Ferodo, Limited, of Chapel-en-le-Frith.

BRITISH INDUSTRIES FAIR.—The Birmingham and London Sections of the British Industries Fair will run concurrently from February 19 to March 2, 1923. Every effort is being made to make the Fairs thoroughly representative of British trade, and from Birmingham it is reported that many former exhibitors have increased their space, while new firms have come in. In the interests of the country it is to be hoped that the Fairs will stimulate trade and give business the impetus which it so sorely needs.

FLOATING DOCK FOR SOUTHAMPTON.—A contract has been placed with Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited, for a floating dock for Southampton, which will be the largest in the world. The dock will be nearly 1,000 ft. in length and will accommodate the Majestic, which has a length of 912 ft., and a gross tonnage of 56,000. The building of the dock is expected to take from six to eight months, and something like 20,000 tons of steel will be required in the construction. The dock will be constructed at the Armstrong shipyard at High Walker-on-Tyne.

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, October 20, at 6 p.m., at the Institution, Storey's Gate, St. James's Park, S.W. Presidential Address by Dr. H. S. Hele-Shaw, F.R.S.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, October 20, at 7.30 p.m., at 39, Victoria-street, Westminster. Lecturette, "Profits and Waste Products," by Mr. G. H. Ayres, M.I.E.E., A.M.I.Mech.E. (Member). Slides and exhibits.

THE INSTITUTION OF PRODUCTION ENGINEERS.—Friday, October 20, at 7.30 p.m., at the Royal Automobile Club, Pall Mall, S.W. 1. Annual General Meeting. Presidential Address by Mr. Max R. Lawrence.

THE INSTITUTION OF MECHANICAL ENGINEERS: GRADUATES SECTION, LONDON.—Monday, October 23, at 7 p.m., at the Institution, Storey's Gate. "Some Factors in the Design of Steam Locomotives," by Mr. R. D. Gauld, M.Eng., of Liverpool, Graduate. Chairman, Lieutenant-Colonel E. Kitson Clark, Member of Council.

THE INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, October 24, at 7.30 p.m., in the Rankine Hall, 39, Elmbank-crescent, Glasgow. First General Meeting. Address by Mr. Harold E. Yarrow, C.B.E., President. Paper on "Sea Power or Air Force," by Colonel Sir Alan Hughes Burgoyne, M.P., will be read and discussed.

THE NEWCOMEN SOCIETY.—Wednesday, October 25, at 5 p.m., at Prince Henry's Room, 17, Fleet-street, E.C. 4, when the following paper will be presented: "Simon Goodrich and His Work as an Engineer." Part I, 1796–1810, by Mr. E. A. FORWARD, A.R.C.S., Member.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, October 27, at 7.30 p.m.; at 39, Victoria-street. Question and General Discussion Evening

THE INSTITUTION OF CIVIL ENGINEERS: YORKSHIRE ASSOCIATION.—Friday, October 27, at 7.30 p.m., at the Philosophical Hall, Leeds. Presidential Address by Lieutenant-Colonel M. M. Bidder, D.S.O., M.Inst.C.E. Discussion of future policy of the association will take place afterwards.

THE STAFFORDSHIRE IRON AND STEEL INSTITUTE.—Saturday, October 28, the Opening Meeting of the Session will be held at the Education Offices, St. James'-road, Dudley, when the president, Mr. Jos. Payton, will give a short address to be followed by an address by the vice-president, Mr. F. J. Cook, on his American experiences in connection with the Iron and Steel Industries. Chair to be taken at 7.15 p.m.

GERMAN BUSINESS WITH RUSSIA.—According to the *Kölnische Zeitung* negotiations between the Siemens-Schuckertwerke and the Electro Trust in Moscow have led to the conclusion of a contract in regard to the delivery of installation material, a preliminary contract having already been signed at Moscow. This contract is the first goods credit contract of a German group with the Soviets.

TECHNICAL COLLEGE, BRADFORD.—A new department under the direction of R. E. Stradling, M.C., Ph.D., M.Sc., A.M.Inst.C.E., has recently been established at the College, and special facilities are now available for students who may wish to obtain a training in the methods of research, or to carry out research in building materials and constructional methods, strength of materials, theory of structures, and hydraulics. Full particulars may be obtained on application to the principal.

BUSINESS CONDITIONS IN THE UNITED STATES.—A general and steady improvement in business conditions in the United States is reported in a cable received by the London office, 32, Lombard-street, E.C. 3, of the Guaranty Trust Company, New York. "The largest volume of peace-time traffic in history" the cable states, "was offered to the railways during the week ending September 30." The crop outlook is reported to be better than last year, 15 out of the 21 leading crops being likely to show a larger yield than in 1921.

DRAINAGE AND SUBSOILING DEMONSTRATION.—The Ministry of Agriculture and Fisheries announces that a drainage and subsoiling demonstration is to be held on the farm of Mr. F. O. Streeten, High Hilden, Tonbridge, on Tuesday and Wednesday, the 24th and 25th inst., from 10 a.m. to 12.30 p.m. and 1.30 p.m. to 4 p.m. each day. The site of the demonstration is on the northern outskirts of Tonbridge, about 1¼ miles from Tonbridge Station (S.E. and C.R.), and can be reached from the Shipbourne-road *via* Little Trench Farm, or from the London-road *via* High Hilden or Hilden House and Latters' Farm.

MOTOR TAXATION.—The Ministry of Transport has issued a table giving the motor and other licences issued from December 31, 1921, to August 31, 1922, and the tax collected in that period in Great Britain. The total gross receipts amount to 10,835,417*l.*, a figure which is subject to some adjustment as regards refunds, &c. It is stated that the receipts during the remainder of the calendar year will be relatively small. The motor vehicles in respect of which licences were current on August 31 included 314,000 cars taxed on horse-power, 377,000 cycles, 150,000 commercial goods vehicles and 77,000 motor hackneys.

PRODUCER-GAS PLANT FOR THE MOSSEND STEEL WORKS OF MESSRS. W. BEARDMORE AND CO., LIMITED.

CONSTRUCTED BY THE INTERNATIONAL CONSTRUCTION COMPANY, LIMITED, ENGINEERS, LONDON.

(*For Description, see Page* 484.)

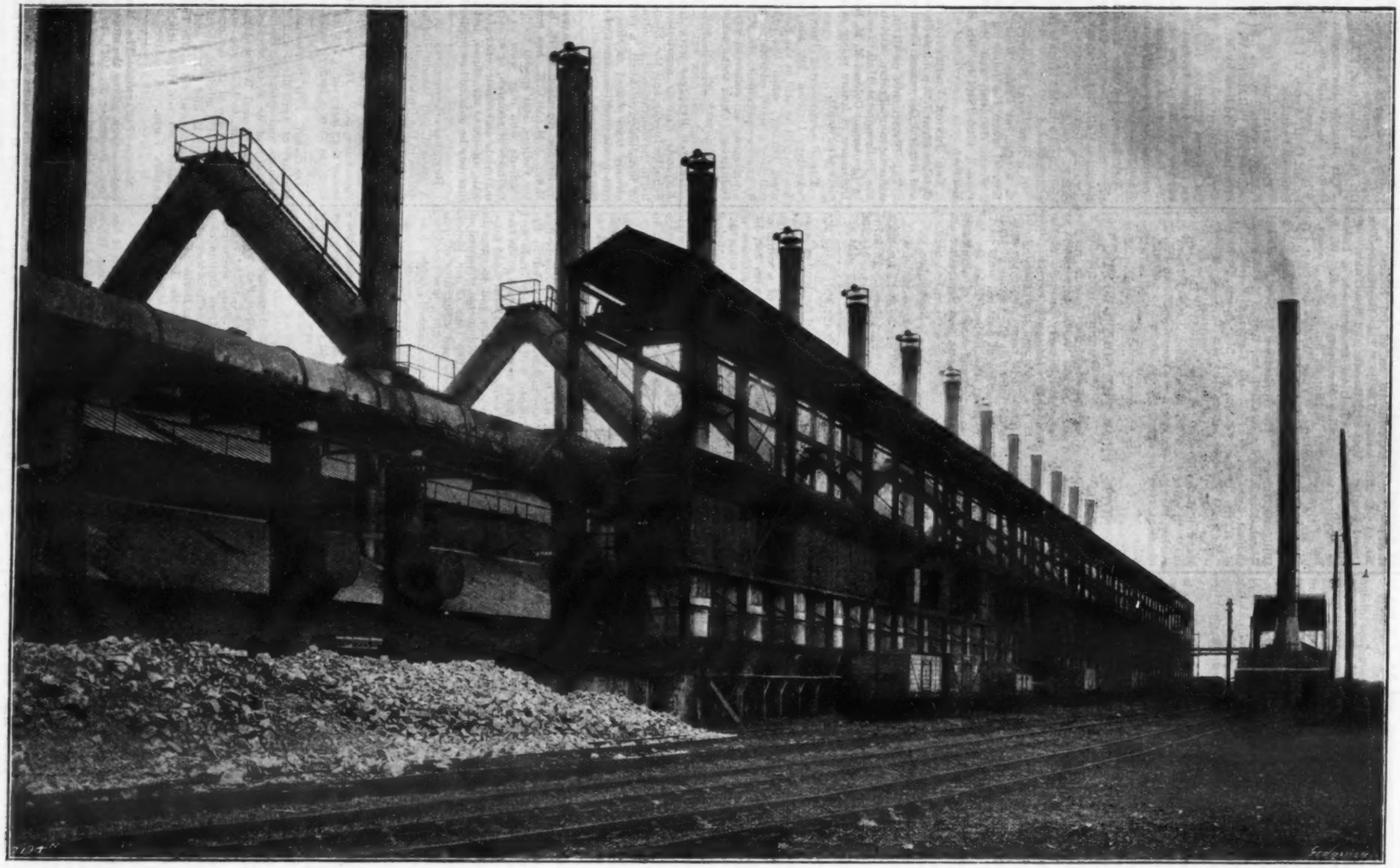


Fig. 5.

PRODUCER GAS PLANT FOR THE MOSSEND STEEL WORKS

CONSTRUCTED BY THE INTERNATIONAL CONSTRUCTIO

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SECTION THROUGH PLANT THROUGH GROUND BIN.

Fig. 6.

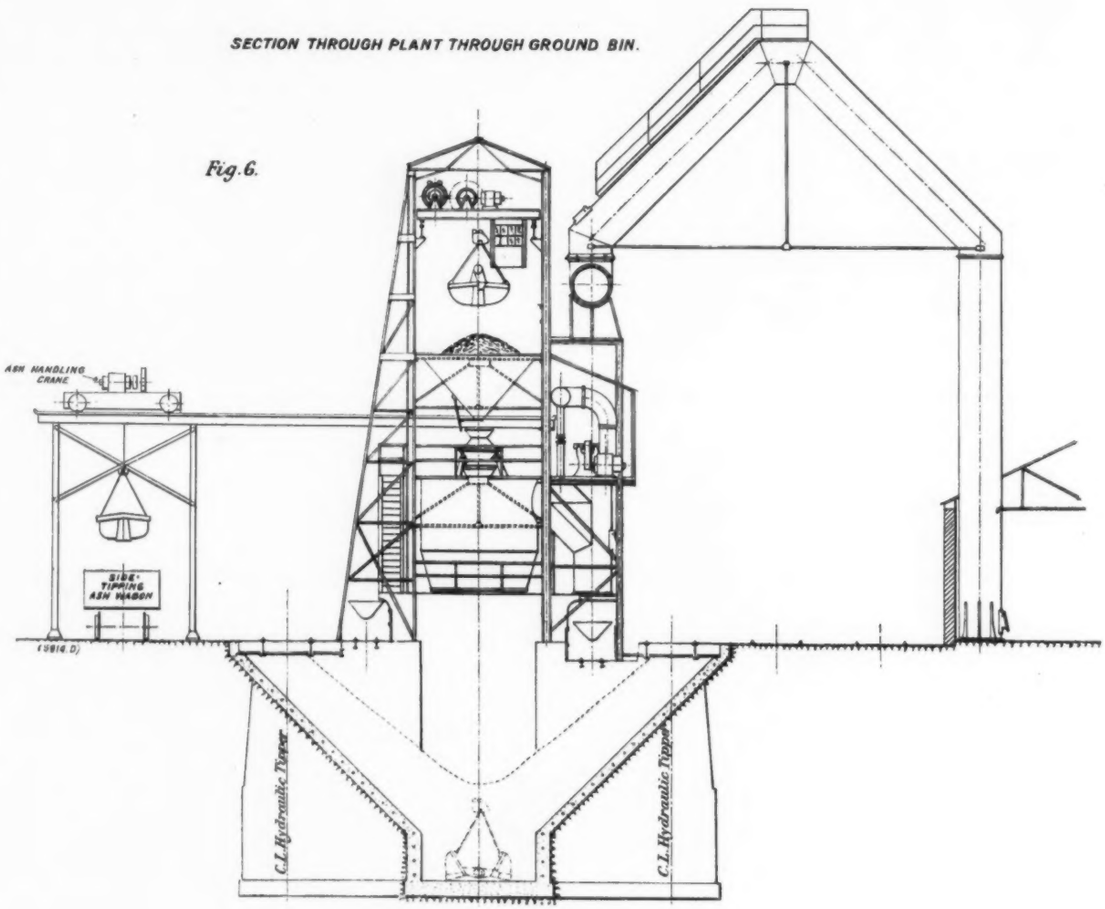

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Fig. 7.

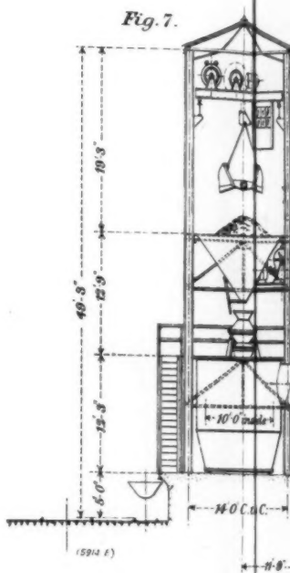
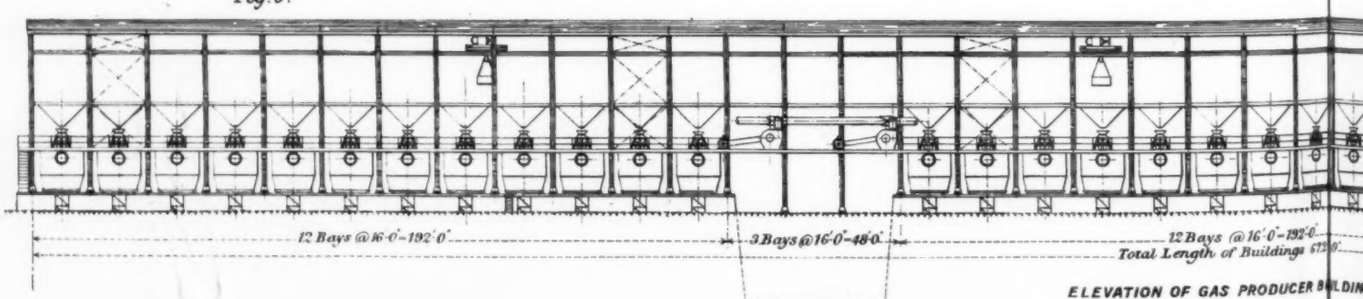
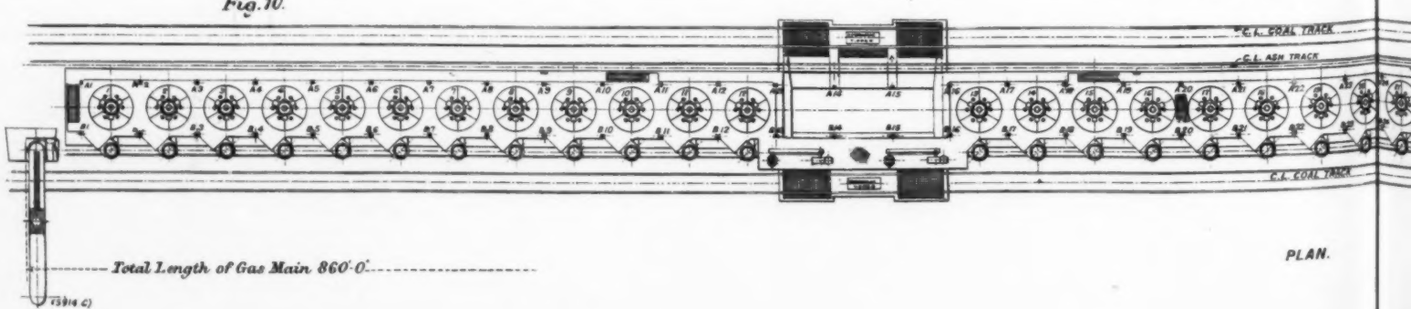


Fig. 9.



ELEVATION OF GAS PRODUCER BUILDIN

Fig. 10.



PLAN.

ORKS OF MESSRS. WILLIAM BEARDMORE AND CO., LIMITED.

CONSTRUCTION COMPANY, LIMITED, ENGINEERS, LONDON.

escription, see Page 484.)

SECTION THROUGH PLANT.

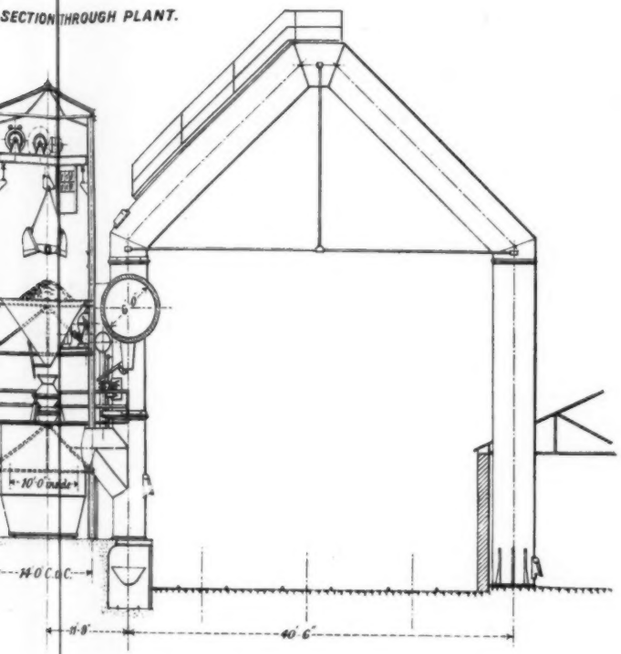
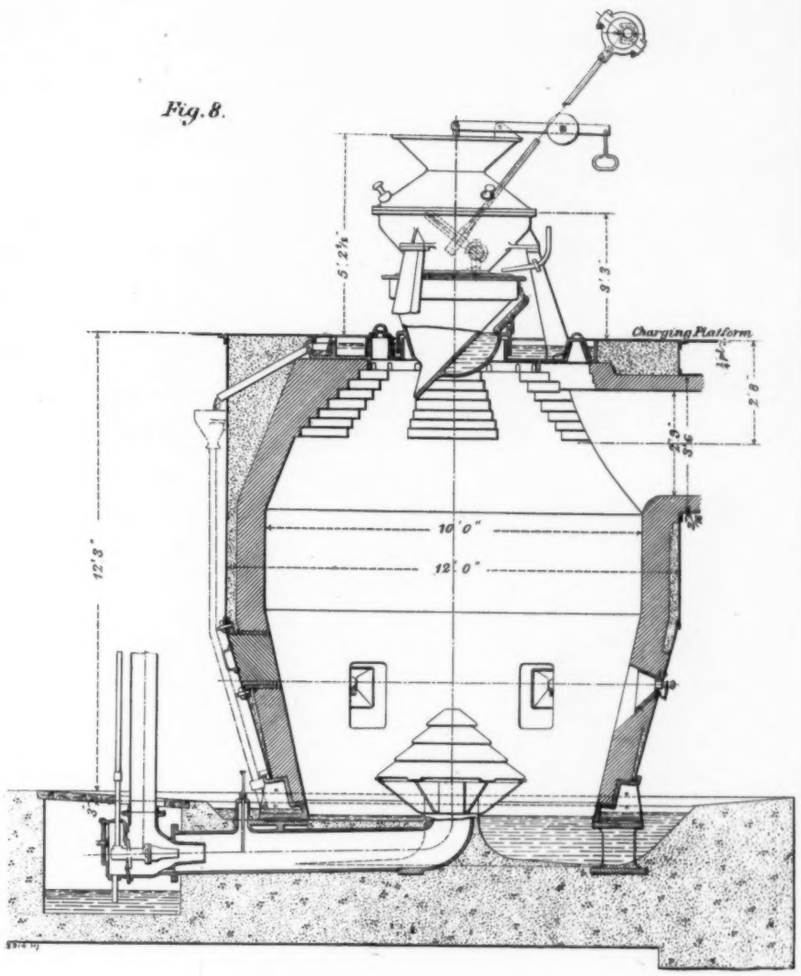
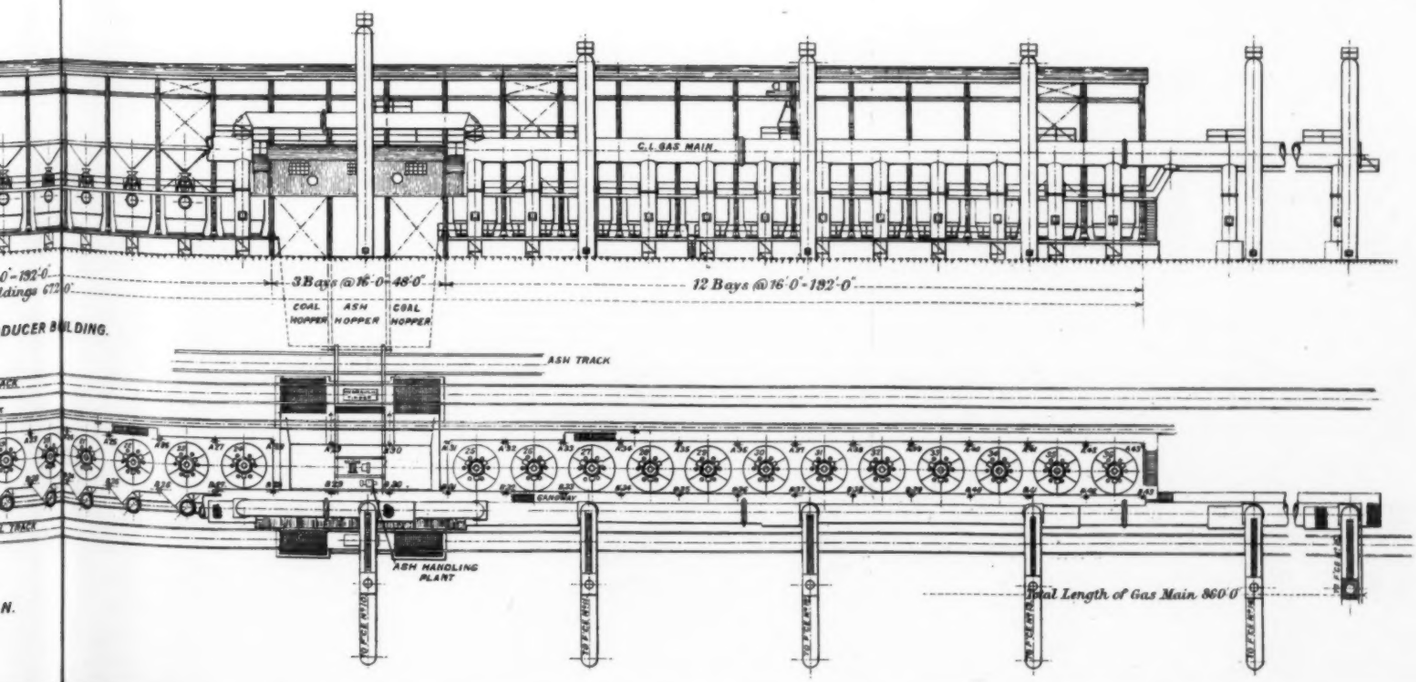


Fig. 8.





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ENGINEERING.

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ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12*s.* per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

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Two-Page Plate.—PRODUCER GAS PLANT FOR THE MOSSEND STEEL WORKS OF MESSRS. WILLIAM BEARDMORE AND CO., LIMITED.

ENGINEERING.

FRIDAY, OCTOBER 20, 1922.

FACTORS AFFECTING THE AUTOMOBILE INDUSTRY.

THE automobile industry has long passed the stage when its most pressing problems were those concerned with the construction of vehicles which would run properly. Technical success has been achieved in every feature of the motor car, and although improvements in detail are still possible, the prosperity of the industry is now largely conditioned by broader considerations. At the present time prosperity cannot be said to be much in evidence, and manufacturers are hard put to it to secure enough orders to keep their works occupied. The reason most frequently given for this state of affairs is that the producing capacity of our automobile factories is many times greater than before the war, while the population of the country is considerably poorer. In other words the trade is said to be suffering from over-production. This is a disheartening and dangerous belief, for it tends to stultify all efforts to promote a renewed healthy activity. If it is to be accepted, it must be on other grounds than those which we have mentioned, for although the premises of the argument are admittedly true, the conclusion arrived at does not necessarily follow from them. It is indeed a sufficient refutation of the cry of over-production in British motor-car factories, to point to the enormous number of foreign-built vehicles on our roads, and the vast sums spent every year in purchasing more from abroad. Foreign manufacturers seem to find a sufficient absorptive capacity in the British public to make it worth their while to maintain elaborate organisations here, in spite of a heavy import duty levied on their products.

In his presidential address on "The Need for a Wider Outlook in Automobile Engineering," delivered on October 12, before the Institute of Automobile Engineers, Lieutenant-Colonel D. J. Smith seemed to recognise that the importations of foreign cars was hardly consistent with the note of over-production which he sounded rather loudly, for he admitted that if only half of the foreign cars entering the British Empire had been made in British factories our automobile industry would be in a very different condition. In another place, to emphasise his contention that suitability rather than price governed the situation, Colonel Smith stated that "The whole of the light delivery vans in use throughout the Empire are foreign-built, the few exceptions only proving the rule," and he even went so far as to say that if the cars in question cost three times their present price the position would be much the same. From these admissions it is clear that talk of over-production is quite out of place until our manufacturers have occupied the field which rightly belongs to them.

We should not have given so much attention to the point, had it not been that Colonel Smith supported his case for over-production by a calculation which we think misleading. He mentions that two years ago the probable car-owning capacity of the country was calculated on the basis of the income-tax figures, and it was found that the normal output of the works then operating, would be nearly four times the absorption-capacity of the population. In this calculation no account was taken of imported cars, and it was further assumed that every car-owner bought a new vehicle within two years. A statement of this kind is of such seriousness that it should not be made without the basic figures being put forward for criticism. How was the "normal output of the works then operating" arrived at? Was it computed from the sanguine anticipations of the company prospectuses of 1919, or from surer data. Again, what was the average price of the cars which the income tax payers were supposed to be able to afford? If Mr. Henry Ford had made a calculation of the kind indicated before starting his works, we doubt very much whether he would now be controlling an organisation giving direct employment to perhaps 100,000 men and indirect employment to millions. Mr. Ford set out with the idea that there was an under-consumption of cars, rather than an overproduction, and he bent his energies to removing the cause which deterred so many people from acquiring motor vehicles. If other manufacturers would replace the thought of over-production by that of under-consumption, and endeavour to bring the price of articles of every kind within the reach of all the people who want them, they might find that there was yet plenty of work to keep their factories busy.

Colonel Smith devoted some consideration to the eternal question of roads, and called on automobile engineers to protest in every possible way when they see large sums of money being spent on questionable improvements or actually wasted in connection with roadmaking. He entered his own protest with regard to what he had recently seen in London, namely, "a main thoroughfare being relaid with soft wood blocks on a doubtful concrete foundation." This kind of work is unfortunately only too common, and may be observed on every hand. The concrete foundations are usually of the poorest character and soon become pressed or battered into holes underneath the wooden carpet, as may be seen whenever a wooden road is relaid. Some of our road authorities appear to think that any kind and any thickness of "mud-concrete" is good enough for road foundations, with the consequence that the best surface is rapidly ruined. With a really good concrete foundation, designed and laid under proper engineering supervision, there is no reason why anything more than the periodical relaying of the surface should ever be necessary, and such relaying, moreover, would be far less frequently required than it is at present. A concrete bridge has not to be rebuilt every time the road surface becomes worn, and there is no reason why a concrete road foundation should be.

Another grievance to road users, which adversely affects the automobile industry, is the congestion of traffic caused by trams. Colonel Smith estimates that a 5-minute tram service reduces the carrying capacity of the road by 50 per cent., which results in an enormous direct and indirect loss to the community. Trams, moreover, are almost universally operated unprofitably, and Colonel Smith

believes that their comparatively early disappearance is certain. The country, he says, cannot afford them. This may be, but in view of the millions of pounds sunk in them, it is probably more true to say that the country cannot afford to scrap them. It is generally agreed that the laying of fresh tramway routes is a wrong policy, but we shall have to endure those we possess for some time longer. Meanwhile, automobile engineers and users are warned by Colonel Smith as to the disastrous effect upon traffic which would result from powers which the London County Council is now seeking. The Council desires authority to prevent any vehicle passing a stationary tramcar, on the grounds of safety to passengers entering or leaving the car. In certain Canadian cities such a regulation has been enforced, but as all these cities are laid out on a "gridiron" plan, the through motor traffic can always take a parallel road only one block distant from the main road. This possibility, together with the wideness of the streets and the comparative sparseness of traffic, mitigates to some extent the obstructive results of the regulation, but it is questionable whether much greater safety is assured by it. What happens in practice is that motorists who observe a car about to stop, usually, of course, at a cross-road, accelerate rapidly and endeavour to shoot past it before it has actually come to a standstill. This is not conducive to safety, which can best be assured by freedom from harassing regulations and by enforcing heavy penalties for recklessness.

No address on matters relating to the automobile industry would be complete without some reference to taxation, and Colonel Smith, in common with all who have studied the matter, spoke very strongly against the system of taxing vehicles on the basis of their cylinder dimensions. This has compelled British designers to produce small high-speed engines which are unacceptable in foreign markets and expensive in our own. The big, moderate-speed engine enables an efficient and amply-powered car to be built at a moderate price, and it is likely that our system of taxation, by hampering the designer, has contributed materially to the poor showing that British vehicles make on the roads abroad. No manufacturer can afford to have two standard designs of engine and transmission gear, one for the home market and another for abroad, and the best design will never be obtained so long as the designer has to keep one eye on taxing regulations.

The general argument of Colonel Smith's address was that automobile engineers should take a more effective interest in questions which, although incidental to their industry, were nevertheless vastly important in their bearing upon its development. They should make the design of roads as much their business as that of the design of vehicles to run upon them. A railway company took care that its tracks suited its rolling stock and would not entrust the maintenance of its permanent way to the borough councils along its route, whose main interest would be to use local material and to find work for local unemployed. The automobile engineer should also see that provision was made for pedestrian traffic along and across roads, so that foot passengers could travel with safety both to themselves and to other users of the roads. Regulations concerning the storage and distribution of petrol ought to engage the attention of the Institution. At present people devoid of practical knowledge passed all kinds of useless restrictions which seriously hindered the development of the industry.

The important work carried out by Colonel Smith in connection with the adaptation of the gas producer to motor vehicles apparently rendered him diffident in speaking so fully on this matter as he might well have done. He, however, forecasted a considerable future for both steam- and gas-driven vehicles, especially in some of our overseas dominions where charcoal is available in ample quantities at prices with which petrol cannot compete. It should be remembered, however, that in some of our dominions the steam vehicle is practically barred by legislation which compels the employment of a qualified engineer to operate steam plant employing a pressure of more than 25 lb. per square inch. This restriction gives an immense advantage to the internal-combustion engine and, with Colonel Smith, we hope that our manufacturers will follow the lead which has been given in this country to the development of the portable gas producer. Colonel Smith also directed attention to the present unsatisfactory conditions governing public-service vehicles, some of which, in Colonel Smith's opinion, were run in the most dangerous mechanical state, either through wear, or neglect, or both. Allied with this is the question of insurance of vehicles, and the practice of many insurance companies of insuring vehicles without inspection was detrimental to the industry. The rates had to be raised to cover the serious risks incurred by such a policy, and good owners were therefore penalised on account of bad ones.

THE PHYSICIST AND THE ELECTRICAL ENGINEERING INDUSTRY.

In addressing the new Institute of Physics last summer, both Professor J. Barr and Sir Alfred Ewing had, in their introductory remarks, referred to the boundary lines between the domains of engineering, physics and chemistry. Mr. C. C. Paterson also alluded to that question, when introducing his address on "The Physicist and the Electrical Engineering Industry" before the same body last Wednesday. But he did so, one might say, rather to classify the engineer—though that was certainly not his avowed object—than to draw up definitions. Some engineers, he remarked, regarded engineering, and particularly electrical engineering, as nothing more than applied physics; whether right or wrong, those engineers were at least to be trusted. Other engineers relegated to the domain of physics only certain parts of engineering which they themselves had failed to assimilate; such might, or might not, be worthy of confidence. To others again there was little difference between chemistry and physics, and still less use for either chemists or physicists, who were a necessary evil which had somehow escaped from a University; such engineers were themselves an entirely unnecessary evil, and ought never to be allowed to attain responsible positions in industry, whether commercial or technical. There were also engineers who were true physicists at heart, and commercial men with a truer appreciation of the functions and the need of the physicist than many men of technical reputations. The introduction was characteristic of the address. Not less characteristic is, perhaps, that Mr. Paterson did not very particularly apply himself to electrical engineering; the fundamental problems of the electrical engineer are not merely electrical.

What Mr. Patterson meant to emphasise is that there is, in nearly every industry, vital work to be done, affecting cost and quality, that only the physicist can do. An industry to be successful must pay, and must pay well, lest the agencies which operate for the cheapening and improvement of design and process, organisation and efficiency suffer. The physicist is, or ought to be, among the chief of these agencies. The electrical industry has a very wide scope of most diverse activities; in many of its departments chemistry has a large share. But the physicist is needed in all of them, and there are three main ways in which physicists may be associated with the industry. They may pursue independent research at Universities, without immediate industrial objects in view; they may work with definite industrial objects, *e.g.*, at the National Physical Laboratory or in the various research associations; they may engage in investigatory work in the employ of an individual company. As chief of the electrotechnical department of the National Physical Laboratory for many years, and since the war director of the Research Laboratories of the General Electric Company (late of Brook Green, W., now of Wembley), Mr. Paterson was well entitled to discuss the last two of his three categories; he spoke mainly on the last, because the need which the industry has for the physicist within itself is not sufficiently appreciated.

The physicist is generally pictured as working under the conditions of the first category, to which science owes its epoch-making discoveries. But few industries supply any funds for such research, and that will remain so as long as people who pay for research expect to control it. Such control will do more harm than good. Mr. Paterson is right in this, but one understands the restrictions. We need not dwell upon research of the second category, standardisation and specification work, that must be entrusted to associations. But the electrical industry can never flourish if relying entirely on physical investigations from outside. For one thing, it is no use to consider the industry as one whole. It consists of a number of entirely independent units, generally competing both as to price and quality. A qualified engineer often has the executive responsibility with respect to putting through orders and to the quality and design of the articles; technical responsibility may also rest largely with the design and drawing office. The staff member responsible for the factory processes is usually given a free hand to make trials and experiments with a view to improvements and cost reduction. Suggestions for alterations in processes and designs may come from inside, or may be due to competitive pressure; the experiments when made in the factory, often on insufficient information as to probable new lines, can rarely be carried sufficiently far, because this or other work will be pressing, and thus the electrical engineering industry "muddles along," in an atmosphere of semi-ignorance and constantly fearing that the articles may develop obscure blemishes.

Those uncertainties, Mr. Paterson insisted, can only be cleared up by a knowledge of the physical laws which underlie the processes and govern the behaviour of the products, and that knowledge must be part and parcel of the factory equipment, and not be regarded as an academic thing, the property of one or two experts. Only thorough physical investigation can explain why materials fail to come up to standard, and why output and performance are limited. At present, causes are too often guessed at, or some explanatory "formula" is accepted. One understands what Mr. Paterson meant when he suggested that the physicist might be said to be a man who believes in laws and tolerates factors of safety, and the engineer a man who believes in factors of safety and tolerates laws. Yet the statement that industry run only by engineers is satisfied by merely getting something to work, whether it be a process or a finished product, was rather harsh. It was made, however, in the course of arguments leading back to the main point that outside research assistance cannot take the place of the physicist at the heart of a concern.

Mr. Paterson's physicist is not merely to straighten out things, to find out the bases of existing processes and to act as works' detective. He has much higher aims; but to start with them would prejudice the whole future. The physicist and those with whom he co-operates have first to learn to understand, to trust and to appreciate one another. The physicist must not expect the technical manager to know instinctively how to apply the physicist's suggestions, nor must the manager expect the physicist to tinker with the surface of a problem and at once to prescribe the proper medicine. But the works manager will expect the physicist to take a lively interest in the dull and monotonous difficulties of the work. The physicist has indeed to live with the works and to learn to judge its personnel, in order to secure support for sweeping changes.

For that purpose the physicist has in the first instance to study the works thoroughly. He must be allowed to measure things moving and stationary; he must have access everywhere, and there must be no secrets between him and the personnel—that would be considered a stiff demand in some chemical works where the director of one department needs permission to enter another department. But many electrical works are largely chemical works. Things are very empirical still in electrical manufactories, and how is control by measurement to be substituted for control by judgment on other lines, when questions of raw materials and their variations come up? To attach the physicist to the staff of the works chemist or even the works physicist would be fatal; they have their own duties. The research physicist—there must be more than one, of course—must be a free lance, as Mr. Paterson put it, free to arrange his own problems, untrammelled by the prejudices of the personnel. The wisdom of letting physicists loose in the works might be questioned, he is aware. There are no doubt

difficulties of discipline, of jealousy and of overlapping duties and responsibilities. The all-important choice of men is, no doubt, a very difficult matter. Mr. Paterson emphasised two points: Experience in the same class of technical problem is not required; the man coming with fixed ideas may be a hindrance rather than a help, especially if coming from a rival research laboratory; but the men must have real capacity and enthusiasm for research.

Several of the groups of firms recently established have founded joint research organisations. A small concern might do with two research physicists as the absolute minimum, one sound general physicist, the other perhaps a metallurgical physicist. The personnel of the research laboratories with which Mr. Paterson is connected now number 80 members, a quarter of whom are qualified research men. The only general principle which the General Electric Company laid down, five years ago, when deciding upon the organisation of their research laboratories, was that research activities were to be kept independent of production activities. Members of the technical and the research staffs meet regularly. The works maintain their complete responsibility for production processes; the research organisation is to assist with advice and to experiment in a consultative capacity, the problems they tackle being left to their discretion. The solution—or attempted solution—of those problems, as Mr. Paterson exemplified, *e.g.*, by referring to troubles various residual gases give in tungsten lamps, may take weeks or years. The chief thing is that the arrangement is absolutely flexible. The Metropolitan Vickers Company and several cable companies have also established research organisations. The former concern includes in the list of problems in hand the use of tidal power, critical speeds and vibrations, and stresses in gearing, problems that might properly be left to institutions. On the whole, Mr. Paterson would preferably start with a medium-size research organisation. That is a consolation to the individual investigator.

NOTES.

The Influence of Iron on Copper.

In the course of his address to the Birmingham Local Section of the Institute of Metals, on the 10th inst., Dr. F. Johnson, the chairman of the section, stated that in copper, iron up to 0·5 per cent. deoxidised, toughened and strengthened copper, even in the presence of arsenic. It had a powerfully inimical influence on electrical conductivity, and a very small quantity made the metal paramagnetic and unsuitable for using in galvanometers. Copper was capable of holding about 3 per cent. of iron in solid solution. In regard to the influence of iron on copper alloys, there appeared to be an overwhelming weight of opinion in favour of keeping the iron content low in alpha brass, say 0·1 per cent., for the reasons that it increased the casting difficulties, the power required for mechanical operations, the annealing costs and corrodibility. For special purposes, such as the manufacture of articles required to be stiff and springy, the addition of iron was advantageous, but in these instances it need not exceed 1 per cent. Advantage might be taken of the influence of iron in raising the annealing temperature of cold-worked alpha brass; a slightly higher temperature of annealing would mean a shortening of the annealing period, an advantage in works practice. But to what extent this would affect the oxidising annealing treatment proposed by Dr. Bengough, or the corrodibility of material so treated, had not been investigated so far. Dr. Johnson also reviewed the action of copper in alpha plus beta brass, and in beta brass. In nickel-brass (nickel-silver) the addition of iron had been specially recommended for cutlery stock and extra hard springs. In copper-aluminium (aluminium-bronze), iron up to 4 per cent. had been found to be very beneficial in reducing grain-size, retarding crystal-growth and facilitating the production of die-castings. In regard to Admiralty gun-metal, iron up to 1 per cent. did not appear to be detrimental if correctly alloyed; the mechanical properties were enhanced under such conditions in the case of small chill castings. In most of the alloys examined, the limit of solid solubility occurred at less than 1 per cent. of iron. In brass there were two forms in which the iron existed in excess of that entering into solid solution, namely, (1) as free, iron-rich crystallites, globular or cruciform in shape; these were pale blue, but turned black when etched; (2) as very minute uniformly distributed, dark-etching particles. As a rule, the beneficial influence of iron ceased at the degree of concentration at which the free crystallites under (1) appeared.

Trade Associations and Costing Methods.

Although much has been said about the value of accurate costing in engineering manufacture, it is certain that there are still a very large number of firms which do not take out their costs in any considerable detail, so that they have no precise knowledge of what any particular article may have cost to produce. This matter was referred to by Mr. Daniel Adamson in his presidential address to the Manchester Association of Engineers last Friday. Mr. Adamson stated that if a standard method of costing could be agreed on by each section of the engineering trade it would be of advantage to all concerned because bad management, unsuitable situations of works, poor equipment and other handicaps would be shown up without the costly interference of the bankruptcy courts and with resulting benefits to the community. This question of standard costing was considered by Mr. Adamson in reference to the question of trade associations, and he quoted a Board of Trade report made under the profiteering Act of 1919, in which it was stated that a certain trade federation circulated a schedule giving the average costs of some of its larger factories, which produced economically, in order that the smaller or less efficient manufacturer could check his costs by them. Work of this kind would appear to be a legitimate and useful activity for a trade association, and anything which tends to reduce the cost of a product while maintaining its quality is to the general benefit. That the matter may, however, be looked at in another way is shown by the quotation that Mr. Adamson gave from the United States Attorney-General. This official stated that there is no apparent objection to a trade association furnishing a standard system of cost accounting and recommending its use, providing that the costs so arrived at were not supplied by the members of the association to each other, either directly or through the association. The idea here is violation of the anti-trust laws, and the opinion expressed may be necessary in American conditions. It is difficult to see, however, that the full value of a standardized costing system can be obtained if its use for comparative purposes is to be forbidden.

Therms and Cubic Feet.

At their meeting on Tuesday last the London County Council adopted a resolution brought forward by their Public Control Committee to the effect that the Board of Trade should be asked to institute an immediate inquiry into the new method of charging for town gas by the therm. This is an incident in an agitation which has broken out in various quarters, and has been much in evidence in some organs of the daily press. The general position appears to be that in some way, of which the details are not stated, the gas companies have taken advantage of the introduction of the therm system of charging to get more money out of the consumer, for the same service, than they got under the old cubic feet measurement. The contention is not that gas has gone up in price, but that there is something baffling and apparently slightly underhand about the therm which enables the companies to get the better of their customers. The attitude of mind which this agitation represents makes one almost despair of popular education, and if the mental confusion with which the subject is being discussed is a fair sample of the reasoning power of the present British public, there is something seriously wrong with our whole educational system. A defence in simple language of the position of the gas companies in this controversy was given by Sir George E. Davies in his Presidential address before the British Commercial Gas Association at Bristol on Tuesday, and in the course of this address Sir George reminded his hearers of the very remarkable difference between the weather of the summer of this year and that of last. This will very naturally have resulted in increased gas consumption in some cases. In others the price of gas may have a bearing, and we note that while during the mid-summer quarter of 1920 the South Metropolitan Gas Company sold gas at $10\frac{3}{11}d.$ per therm, in the corresponding quarters of 1921 and 1922 the prices were respectively $10\frac{1}{2}d.$ and $11\frac{1}{2}d.$ per therm. Obvious and calculable factors of this kind appear to have no part, however, in the remarkable attack which is being made on the therm. If one of the increased gas bills which are being made a basis for attack is compared with the earlier bill with which it is being contrasted, and the consumption in the two cases, either in therms or cubic feet, is compared, it will be found that the increase is a matter of simple arithmetic, and has no relation to any malign quality in the therm. It is difficult to believe that this elementary and obvious procedure is beyond the mental capacity of the British public, but some of the present procedure suggests that it is.

Unbalanced Railway Traffic.

A lecture, to which the somewhat cumbersome title was given of "The Effect on Traffic Arrangements and Working Costs of Daily and Seasonal or Periodic Variation in Passenger Loads and Unbalanced Traffic Movement," was delivered on Tuesday last before the graduates and students' section of the Institute of Transport. This lecture was delivered by Mr. C. J. Selway, C.B.E., of the Great Northern Railway, from which system most of the lecturer's examples were taken. Mr. Selway considered his subject in three sections which dealt with (*a*) suburban services, (*b*) secondary main line, or branch services, and (*c*) long-distance services. The actual figures which Mr. Selway gave serve, to some extent, to focus the mind on matters on which often even the railway official is sometimes found to possess only vague notions. In the Great Northern Railway suburban service about two-thirds of the trains fall out of service as soon as the rush is over, and for these siding accommodation has to be arranged, and the stock stands idle till the evening. Each rush is so short that it does not provide a full day for the train crew, while the two in each day are separated by so long a period as to exceed the working day, and fresh crews have to take over, for whom in turn it is difficult later on to find work. Another inconvenience resulting from the traffic is caused to freight working from London yards. Within the rush hours no trains are allowed out of such yards on to the running roads, so that hours of freight-train working are restricted. In cases of engines working freight to south of the Thames the outward and return trip have both to be worked in between the hours during which the yards are closed. As regards secondary main line services, special arrangements have to be made for fairs, market days, &c. These, however, are of regular occurrence and the stock required can be as a rule readily arranged. In main line traffic apart from special events, the day of the week has a great influence on traffic. Among first-class passengers in summer and winter, traffic is greatest on Monday and least on Saturday; in third-class traffic in summer it is heaviest on Saturday and least on Wednesday, and in winter heaviest on Monday and least on Thursday. Holidays and special events involve extra traffic, but the traffic fluctuation is as a rule much greater than the change in mileage. Sleeping car traffic is badly balanced. In summer it is 54 per cent. greater than in winter, while at the holiday time 100 outward berths from London will be required for every 63 inward berths, and later for every 100 berths occupied on outward trains, 159 will have to be provided on inward trains. These conditions involve empty working of stock. Sometimes race traffic only gives a working one way. For instance, the specials to the Lincoln spring races are only partly utilised on the return, as many of the passengers go on direct to the Liverpool meeting. The Great Northern has a stock control in operation giving a daily report of the use of each vehicle, maintained on a card index system; this has enabled stock to be put to the best use, and for emergency requirements to be fulfilled with the least possible empty stock movement.

THE GENERATION AND UTILISATION OF COLD.

The president of the Faraday Society had a regrettable announcement to make on taking the chair at the discussion on the "Generation and Utilisation of Cold," held last Monday. Professor H. Kamerlingh Onnes, the director of the famous Cryogenic Laboratory of the University of Leiden, was to have opened the discussion. His health making a journey inadvisable, Professor Onnes had asked his colleague, Professor J. P. Kuenen, to take his place. But this information reached the Faraday Society almost simultaneously with the news of the sudden death from aneurism of Professor Kuenen. Fortunately, Dr. C. A. Crommelin was able to represent the Cryogenic Laboratory at the meeting. There were other disappointments for those present, however, for Mr. Georges Claude, of Paris, and other expected visitors, were also unable to attend.

The discussion took place at a joint meeting of the Faraday Society and of the British Cold Storage and Ice Association, and was held in three sessions from 2.30 p.m. in the hall of the Institution of Electrical Engineers. The presidents of the two bodies, Professor A. W. Porter, F.R.S., and Mr. George Goodsir, presided over the first two sessions, and Mr. James Swinburne, F.R.S., a past-president of the Faraday Society, took the chair in the evening after the dinner interval. The British Coal Storage and Ice Association, Mr. Goodsir remarked when opening the second session, has recently been formed by the amalgamation of two societies dating from 1900 and 1910 respectively, and this meeting was the first official gathering of the new association. We may add that a full report of the discussion will be published in booklet form, and that further contributions to the discussion should be addressed to the Secretary of the Faraday Society, 10, Essex-street, W.C.

Refrigeration and Inversion Points.

In his opening remarks, Professor A. W. Porter stated that, since heat would not spontaneously flow from a cold to a hot body, we had to perform mechanical work to effect refrigeration. Theoretically that would best be done in a reversed Carnot cycle by compressing and expanding the working fluid in a cylinder as in a steam engine, but in the reversed sense. In refrigeration the cylinder expansion was conveniently replaced by expansion through a throttle valve. Less external work was then done than would be done in cylinder expansion, and more external work was required in the former case to effect the same change. The work to be done in throttle expansion with volume and pressure changes from v_1 to v_2 and from p_1 to p_2 was only $p_2 v_2 - p_1 v_1$, whilst it was $\int_1^2 p\,d\,v$ in the engine. The difference between these two quantities was equal to $\int_1^2 v\,d\,p$, and Professor Porter called that work which failed to be done the "shirk." The equation-characteristic of expansion through a throttle was: internal energy $+ p\,v =$ constant; that quantity (on the left of that equation) was generally known as total heat, but it was not really heat in general, and he preferred to call it "enthalpy," as Kamerlingh Onnes had done.

Having given reasons for this preference, Professor Porter pointed out that throttle expansion, adopted for convenience in order to produce cold, would produce heating at sufficiently high temperature, as was well known. In the cases of hydrogen and helium this "inversion" occurred at moderate pressures at ordinary temperature; in such cases pre-cooling of the gas before expansion was necessary for the liquefaction. What Professor Porter wished to emphasise, since it was not so generally known, was that there was in most, if not all, cases also a minimum temperature at which the cooling would take place by expansion. Such a point had experimentally been demonstrated by C. F. Jenkin and Pye in 1913 for carbon dioxide to lie between $-20{\cdot}7$ deg. and -31 deg. C.; by plotting their data Professor Porter had calculated that the point should lie near -24 deg. C., when the pressure would be about half the critical. That was remarkable with respect to the use of throttle-expansion at low temperature, and also because it showed that liquid CO_2 behaved, in this region, very nearly like a perfect gas, the volume change being nearly proportional to the absolute temperature. Professor Porter had, moreover, pointed out even in 1906 that all the well-known equations of state, notably those of Dieterici and of Van der Waals, concurred in showing that such points should exist. The equations indicated that, if there were any inversion at all, there should be two inversion temperatures (not one only) for any one pressure; but above a certain pressure, heating should result, when a gas passed through a throttle, for all temperatures. That fact had an important bearing upon the production of exceedingly low temperatures. For instance, the cooling coefficient in the throttle effect was still often taken as being inversely as the square of the absolute temperature, as given by Kelvin, whereas for CO_2, at -25 deg. C. and half the critical pressure, there should be no cooling by expansion and at lower temperatures there should be heating.

After his introductory remarks, Professor Porter called upon Dr. C. A. Crommelin to give an abstract of the opening address by Professor H. Kamerlingh Onnes, the subject of which was the lowest temperature yet attained.

The Lowest Temperature yet Attained.

In his address Professor Kamerlingh Onnes first paid a tribute to the distinguished work in thermodynamics, especially on the equilibria of the liquid and gaseous phases of mixtures, which had been done by his late colleague, Professor Kuenen, whose participation in the discussion of industrial processes would have been particularly valuable. Passing then to the low-temperature work, which had occupied him at Leiden for forty years, Professor K. Onnes indicated how the importance and the scope of these researches had widened in the course of the investigations. Working with liquid air had shown the need of liquefying hydrogen. Before that was attained helium was discovered on which now the hope of further progress centred. But before helium was liquefied, Planck's quantum hypothesis lent a totally new aspect to low-temperature work, and after the liquefaction of helium super-conductivity opened up an entirely new field of research. The main part of Professor Onnes' paper dealt with the attempts to approach the absolute zero of temperature.

On the day on which liquid helium was first seen Professor Onnes had tried to solidify helium by evaporating it at reduced pressure. When the gas pressure was diminished to 1 cm., helium did not cease to be a liquid. With the aid of a Burckhardt vacuum pump of a capacity of 360 cub. m. per hour,* the pressure was reduced to 2 mm.; yet the liquid helium did not lose its extraordinary mobility, though the edge in the capillary looked less sharp than before. A separate cryostat was then added to the liquefying apparatus which itself had already become very complex; the liquid helium was transferred to this cryostat, which serves as a bath (provided with multiple Dewar jackets) for maintaining definite temperatures. In this apparatus the 30 cub. m. of helium, which the American Navy presented to him in 1919, and the 6 cub. m. given by Professor J. C. McLennan (Canada) could be circulated, and the cold could better be utilised. In the cryostat 500 cub. cm. of helium could be kept evaporating for several hours at 3 mm., and formerly impossible experiments could be conducted. Yet helium would not solidify at pressures of 2 mm. and finally at 0·2 mm., though the temperature went down to 1·15 deg. K. (absolute). The pump valves, originally closed by springs and later operated by mechanical means, were then taken out, and the suction pressure was diminished down to 0·04 mm. and even to 0·025 mm.

In this further work a battery of twelve Langmuir pumps (some made of glass, others of iron) was in 1920 added to the equipment. The copper trunk pipe with which these battery pipe connections unite has a diameter of 12 cm. (5 in.); these and other parts are cooled by air blasts to minimise the amount of radiated heat leaking in. But the radiation difficulties increase as the surfaces increase; further to keep frictional heat down, a liquid-hydrogen coil was inserted in one part. The pressures were determined with the aid of the electric resistance gauges of Professor Onnes and Mr. van Gulik. The Gaede-Langmuir pumps were presented by the Philips Lamp Works, of Eindhoven; the glass-blowing, on which so much depends, was done by Mr. Kesselring; Mr. Flim is the head of the technical department. One striking peculiarity observed was mentioned. When helium boils in a vessel so jacketed with liquid helium that the vapour distilling over from the one vessel can condense in the other, and the levels of the two liquids are different to start with, evaporation always tends to make the levels equal; to explain that peculiarity further knowledge of the viscosity of the liquid helium and its vapours and of the thermal properties of glass is needed. Liquid helium has a maximum density.

In the final experiment, the apparatus is evacuated, 50 litres of liquid air having been prepared on the previous day, and 24 litres of hydrogen are liquefied in the early morning. By noon the liquefied helium can be syphoned over into the cryostat and the bath is further cooled by circulation. Observations, partly made with the aid of a telescope, in the afternoon have so far not disclosed any traces of solidification of the helium or of losses of its mobility. The lowest temperature reached is estimated at a few hundredths of a degree Centigrade below 0·9 deg. K. This temperature at present appears to be the lowest temperature limit attainable, since the discovery of a more suitable gas than helium is improbable from our present knowledge of atomic structure. The approach to absolute zero temperature has been very slow, moreover; it has taken more than ten years to come down from 1·15 deg. K. to 0·9 deg. K.

Dr. Crommelin then gave a general account of the work done in the cryogenic Laboratory of the University of Leiden, which we believe is essentially dependent upon State funds, though an institution of this exceptional standard does not make appeals for support in vain.

The Leiden Cryogenic Laboratory.

Dr. C. A. Crommelin pointed out that their object was to produce any temperature below zero and to keep it constant within 0·01 deg. for several hours, in order to make accurate physical measurements. It was done by keeping liquefied gases, well stirred, boiling at different pressures, atmospheric or very low pressures of a few millimetres or fractions of a millimetre. Higher pressures were used only in the auxiliary apparatus; the construction of cryostats, constant-temperature baths, at higher pressures would be very difficult and even dangerous. The temperature range available for such research was the region between the boiling-point of a substance and its triple point, *i.e.*, the point at which the gas, the liquid and the solid were in equilibrium. The following table gives the boiling-point (B.P.), the triple-point temperature (Tr.P.t.) and the critical temperature (t_c) in degrees Centigrade, the triple-point pressure (Tr.P.p.) in centimetres, and the critical pressure c_p in atmospheres:—

Substance.	B.P.	Tr.P.t.	Tr.P.p.	t_c.	c_p.
	deg. C.	deg. C.	cm.	deg. C.	atmos.
Methyl chloride	− 24·1	−103·6	—	+143·0	65·98
Nitrous oxide ..	− 89·8	−102·4	—	+ 36·5	71·65
Ethylene ..	−103·72	−169·0	—	+ 9·5	50·65
Methane ..	−161·37	−183·15	7·0	− 82·85	45·60
Oxygen ..	−182·95	−218·4	±0·2	−118·82	49·713
Nitrogen ..	−195·78	−209·86	9·64	−147·13	33·490
Neon ..	−245·92	−248·67	32·35	−228·91	26·86
Hydrogen ..	−252·76	−259·14	5·07	−239·91	12·80
Helium ..	−268·83	<−272	0·002	<−267·84	2·26

There were gaps in the available ranges; for instance, between -218 deg. and -253 deg. C. we had only neon, which, boiling at -246 deg. C., afforded only a small range for the cryostat work.

The regenerative cycle used for descending to lower and lower temperature on the cascade principle was a modification of the cascade of Pictet, of Geneva. In the ordinary practice three substances were used, methyl chloride, ethylene and oxygen, and in connection with both suction pumps (mostly of the Burckhardt type) and compression pumps (Colladon). In the first cycle methyl chloride boils in a flask of German silver; the vapours are withdrawn by the suction pump at

* The operations will better be understood from the next paper read.

— 90 deg. C. and a pressure of 1 cm., and delivered to the compression pump (5 atmospheres) which returns the vapours to the flask (or to the reservoir); these parts form a closed circuit. In the flask is then inserted a coil through which ethylene is circulated, this coil belonging to the second cycle which contains the same parts in series as the first; the compressor of the second cycle delivers compressed (not liquefied) ethylene at 6 atmospheres into the top of the coil mentioned, in which the ethylene is liquefied. When the apparatus is working properly, no dew or snow will appear on the external pipes (mostly copper), and such indications of waste of cold were, Dr. Crommelin remarked, in fact hardly ever seen in the Laboratory. This cycle yields a bath of — 150 deg. C., sufficiently cold to liquefy oxygen. The third cycle differs from the other two. It consists of a Brotherhood compressor lubricated with glycerin and water, compressing oxygen in three steps to 20 atmospheres; this compressed oxygen enters a spiral in the ethylene flask in which it is liquefied.

The oxygen, Dr. Crommelin continued, was obtained from liquid air, not liquefied in this elaborate way, but by the aid of four compressors and two large vacuum pumps; the installation was not so simple as a Linde or Claude installation, but it required no more power. Oxygen boiling under a pressure of a few millimetres giving a minimum temperature of — 217 deg. C. only, that gas cannot be used for the liquefaction of the next gas (disregarding neon), hydrogen, which has a critical temperature of — 240 deg. C. Here the Joule-Thomson effect is utilised as in the Linde machine; but the hydrogen, and the helium likewise, have to be preheated before throttle expansion (as stated above). The apparatus used for the liquefaction of these gases, of neon—Mr. G. Claude presented a mixture of neon and helium, yielding a few hundred litres of neon—and other gases, and the determination of their constants is effected in partly highly complex apparatus. The hydrogen is purified by making a spray of hydrogen pass over the outside walls of a high vertical hydrogen coil; neon is purified by sucking it, at extremely slow speed, through a coil, the impurities being deposited on the inside. Floats and electromagnetic devices for stirring are employed; a partial reheating of the hydrogen by electric coils is automatically controlled by the gas pressure. The safety precautions, necessary in the Laboratory, are so effective that no serious explosion has ever occurred in thirty-five years, and nobody has been hurt. One feature mentioned by Dr. Crommelin made the professors present envious. Every flask, condensation coil, pipe, &c., is used for one gas only; that involves high initial outlay, but it means an immense saving in time and worry, while it also ensures the reliability of results, and raises the safety of the operations. About a dozen investigators can work independently in the Laboratory at the same time.

Ethyl Chloride C_2H_5Cl.

Professor C. Frewen Jenkin, of Oxford, gave an interesting account of the investigation of the thermal properties of ethyl chloride which he is carrying out for the Food Investigation Board. Ethyl chloride is a very convenient material for refrigeration, industrially almost new to this country; but it has some unpleasant properties. A colourless liquid of pleasant smell, a little lighter than water, boiling at 12·5 deg. C., it may be stored in glass bottles and cylinders of quite moderate strength, but it is very inflammable and in some ways corrosive. It is also an anæsthetic, but must be inhaled in considerable strength to have effect. The latent heat at 0 deg. C. is 93·7 calories; the specific heat of the liquid is 0·348 at — 30 deg. C., and 0·413 at + 40 deg., of the gas 0·22 to 0·28; the specific volume of the liquid is about 1 cub. cm. per gramme between — 30 deg. and + 30 deg. C., while the saturated gas occupies 297 cub. cm. and 1,305 cub. cm. at + 20 deg. and — 20 deg. respectively. The vapour pressures are 2·03 lb., 5·7 lb., 8·9 lb. per square inch, 1 atmosphere, 27 atmospheres, respectively at temperatures of degrees Centigrade — 30, — 10, 0, + 12·5, + 30.

Ethyl chloride does not attack most metals, but the liquid contaminates mercury so that mercury gauges should not be used for pressures less than atmospheric. It also makes rubber swell and soften, slightly so even when the material is vulcanised; woods, except lignum vitæ, also swell in ethyl chloride; bakelite is hardly attacked. The action of ethyl chloride on water is peculiar. The ethyl chloride dissolves some water, but can be dried again by the aid of calcium chloride; when ethyl chloride evaporates from a dish, ice crystals are formed by condensation of the moisture, and in these tubular crystals the chloride is sucked up as in sponge, so that the crystals grow rapidly, half an inch or so long. Valves may be choked in this way. In laboratories temperatures of — 20 deg. C. can quickly be obtained by means of ethyl chloride. For mechanical refrigeration a compression cycle and a Roots blower may be used; the pressures required for common temperature ranges are very low, 19·4 lb. and 3·5 lb. per square inch absolute for the range of ± 20 deg. C. Oil must not be used for lubrication; glycerin answers also for sealing the valves, &c., lest air leak in on the low-pressure side which would accumulate in the condenser. The glycerin and ethylchloride separate again by gravity.

Owing to the low pressure the volume and cross section of the pump are enormously large, but the apparatus is safe. Reciprocating pumps are unsuitable because the lubricating glycerin would absorb moisture and carry it into the system. The inflammability is the greatest drawback; to eliminate this, so-called "non-flam ethyl chlorides" are put on the market, mixtures of ethyl chloride and much bromide (60 per cent.). The bromide resembles the chloride, but it is not inflammable—it is an extinguisher in fact—and heavier, and needs special separators. Commercial ethyl chloride contains some methyl chloride; this is not a disadvantage as the impurity raises the vapour pressure.

Thermometric Lag in Cold-Storage Practice.

Dr. Ezer Griffiths, of the National Laboratory, read two papers. An abstract of the first, having the above title, a joint paper by Dr. Griffiths and Mr. J. H. Awbery, will be found on page 508 of this issue.

Some Materials of Low Thermal Conductivity.

From the point of view of the refrigerating engineer, Dr. Ezer Griffiths pointed out in his second paper, the ideal material for cold-storage insulation would be an assemblage of minute gas cells totally enclosed in frame-work so as to be impermeable to moisture. Water-logged material was useless for insulation; water not only conducted heat ten times better than most insulators, but it also caused decomposition; that would rule out cotton waste and sawdust. The weight of the material was very important, especially for marine work. The following particulars of two ships of the Nelson line, insulated throughout, were due to Mr. A. R. T. Woods: Ship "A" of 7,494 register tons, built in 1911; weight of hull, boilers, engines 4,490 tons; refrigerating machinery and brine piping 610 tons; insulation (silicate cotton) and timber, 1,050 tons; total ship weight empty 6,150 tons; total cargo capacity, 328,980 cub. ft.; capacity for chilled meat; 3,100 tons, for frozen meat, 3,300 tons. Ship "B," of 8,442 register tons, built 1920; weight of hull, &c., 4,624 tons; refrigerating plant, 686 tons; insulation granulated cork, 430 tons, timber, 660 tons; total ship weight, empty, 6,400 tons; cargo spaces as above, 414,570 cub. ft.; 3,540 tons, 4,150 tons. The silicate cotton parts weighed 22 lb. per cubic foot, the cork 7 lb. The common insulators now in use were cork (slab and granulated), slag wool and charcoal.

The first new material examined, expanded rubber, had a structure of minute cells bounded by rubber membranes; the samples differed much as to density and hardness, features apparently under the manufacturer's control; the soft variety had densities ranging from 0·059 to 0·12 (3·7 lb. to 7·5 lb. per cubic foot); the density of the hard variety resembling ebonite, was 0·17, that of red rubber 1·3 to 1·77 (82 lb. to 110 lb. per cubic foot). The expanded rubber clippings, packed, would only weigh from 2·6 lb. to 4 lb. per cubic foot, and half the weight of this material had the same insulating efficiency as the full weight of granulated cork. The permeability to water and water vapour and the durability of expanded rubber required further investigation. Balsa wood, the second new material, the wood of a large tree from Ecuador, was the lightest wood known, weighing only 5·7 lb. to 8·6 lb. per cubic foot (mahogany, 45 lb.); it could be better worked with sharp tools than cork, but it was mechanically weak, and had to be impregnated or coated with a bituminous paint or to be supplied with a veneer of hard wood. Other materials tested on behalf of the Engineering Committee of the Food Investigation Board were the waste fibres of Kingia Australis, a tree growing on the poorer soil of the Coast belt of Western Australia, about 20 ft. high; the American eel-grass mats, made out of cured eel-grass sewn in between sheets of strong paper (the grass grows in salt water, is highly siliceous and does not harbour insects) and finally compressed peat, which is rather heavy, weighing 20 lb. to 30 lb. per cubic foot.

Measurement of Low Temperatures.

Mr. C. R. Darling, of Finsbury Technical College, recommended in a short paper the use of a flexible thermo-couple of Hoskins' alloys and a portable indicator of the pivoted moving-coil type for determining the congealing points of certain oils and other liquids. The instrument had been calibrated at the National Physical Laboratory down to — 200 deg. C., and the apparatus had proved satisfactory, being preferable to a pentane thermometer because it responded more rapidly and could be used in metal enclosures under conditions when pentane thermometers would not be visible. Recently checked by means of solid CO_2 the instrument had been found to maintain its accuracy. For large cold-storage work resistance thermometers, joined to a switchboard, seemed best suited. But care should be taken to use proper, well-protected materials; he had recently found a switchboard, made of lightly nickel-plated brass, badly corroded by ammonia vapours.

Industrial Liquefaction and Application of Low Temperatures.

The paper by Mr. K. S. Murray, M.I.Mech.E., on "Industrial Methods of Liquefaction and Practical Applications of Low Temperatures," was highly appreciated by the meeting, because it gave detailed information about the Linde and Claude processes, never, we believe, previously published, as well as a reliable comprehensive review of the present state of the oxygen industry. Mr. Murray limited himself to this latter domain, which is his own, and he could not enter into constructive detail on this occasion; an abstract of his paper will be found on page 509 of this issue.

Hydrogen from Water-Gas and Coke-Oven Gas.

In the absence of Mr. George Claude, of Paris, his paper on "The Manufacture of Hydrogen by the Partial Liquefaction of Water-Gas and Coke-Oven Gas" was read by Dr. H. Borns. We reproduce this paper on page 506 of this issue. The point he made is that hydrogen manufacture by water-gas liquefaction would hardly offer advantages over other processes; but the compression and liquefaction of coke-oven gas would enable us to strip the gas much more successfully of benzol and ethylene than is possible at present and would give us an enriched purer gas not liable to cause trouble in distribution.

Applications of Gases in Aeronautical Work.

We hope to publish an abstract of this paper read by Mr. Edgar A. Griffiths, of the Air Ministry, in a future issue. Mr. Griffiths dealt at some length with the various processes and uses.

The Metallurgical Aspect of the Production of Cold.

This paper, by Mr. Cosmo Johns, of Sheffield, read in his absence by the Secretary, Mr. F. S. Spiers, B.Sc., will also have to stand over for the present; it deals with the possibilities of enriched oxygen-air rather than with refrigeration.

In the general discussion, which began about 9 p.m., many questions remained unanswered owing to the absence of the authors; Mr. Murray had also been unable to stay for the evening session. Mr.

E. A. Griffiths had to answer a good many questions. The general, very low efficiency of refrigerating plants was commented upon by Professor Jenkin and others; a good deal of that is explained by the need of providing extraordinary safeguards, but those after all are essential features of any installation. That the expansion work is hardly utilised as motive power in Claude plants, was mentioned by Dr. J. A. Harker; in the four or five plants he had seen the energy recovered was turned into a resistance coil. Dr. Harker looks forward, like Mr. Cosmo Johns, to a great development of the oxygen industry. Mr. Briar, of Glasgow, who had had furnace tuyeres fused by oxygen, was sceptical as to its applications; Dr. Maxted also spoke of such troubles. Mr. Swinburne replied to these. Dr. Maxted further wanted more data on the transference of heat from surfaces to gases, and also processes which gave both the constituents of air (not only one) in the pure condition. Dr. Crommelin was heartily complimented upon his communication and the work done in Leiden. It was not possible, however, to question him too much on his complex apparatus, and the technical men were rather silent. The Liquid Air Company gave demonstrations during the meeting, but they did not offer any information about their Heylandt process. The discussion is, as we stated in our introduction, not yet closed.

NOTES ON NEW BOOKS.

It is one of the principles of English law that everybody is supposed to understand it, in spite of the fact that the true meaning of any Act of Parliament is not known to lawyers themselves until somebody has been put to the expense of taking a test case to the House of Lords. Until the day comes when our laws will be intelligently coded by competent jurists, as has been done on the Continent, the best that engineers and manufacturers can do is to make themselves familiar with trustworthy expositions of the laws which particularly concern them. The law concerning trade marks has recently been amended and Messrs. Haseltine, Lake and Co., of 28, Southampton Buildings, Chancery-lane, W.C. 2, have now published a little book entitled "*Information on the Subject of Trade Marks*," primarily for the guidance of their clients, but sold at the price of 10*s.* 6*d.* to the general public. This little work gives an interesting historical account of the principles underlying the development of trade mark law and explains as clearly as possible how the law now stands. There is, moreover, much pertinent advice on the choice of suitable trade marks, and on their registration in foreign countries. The book is well written and is really quite interesting.

It is all too rarely that any Government publication is of interest to anybody outside the department that issues it, so that when a really useful publication appears the department concerned should get the credit it deserves. In "*Oxy-Acetylene Welding*" we have a 16-page pamphlet emanating from the Directorate of Research of the Air Ministry, which is a model of its kind. It is published by H.M. Stationery Office, Princes-street, Westminster, S.W. 1, at the price of 10*d.* post free, and is well worth the money to any one interested in the welding of metals by the oxy-acetylene flame. The booklet is essentially practical and advises the operator how to manipulate his apparatus, what wire to use for different plate thickness, what fluxes to use for different metals, and in fact explains "all the tricks of the trade." The gas consumptions of different sizes and types of blowpipe are tabulated, and there is in addition a vast amount of general information and advice, plainly and concisely given. No person, of course, can become an expert welder merely by reading books, but an average welder will probably become a better one if he assimilates the contents of the pamphlet we have mentioned.

So much is now written on the fixation of atmospheric nitrogen that one looks for technical detail rather than for summaries and retrospects. But there is always a need for short semi-popular books and monographs, and as such we can certainly recommend the "*Industrial Nitrogen*" of Mr. P. H. S. Kempton, B.Sc., A.R.C.Sc. [Sir Isaac Pitman and Sons; 2*s.* 6*d.* net.] Mr. Kempton writes with care, in a scientific vein, likely to instruct and to interest; he has followed the development of the industry and he does not worry the reader with ancient or modern patents. We are not certain that it was wise to devote about 10 pages out of a total of 104 to Dyes; the title of the book justifies that, but it might have been better to adopt the title: "Nitrogen Fixation." Schönherr spells his name with ö (not o) and Kowalski with an i (not y). The reader will look in vain for mention of the Oppau explosion; but one will readily admit that Mr. Kempton has made a good use of the space at his disposal.

MATHEMATICS AND GEARED DRIVES.

To the Editor of Engineering.

Sir,—I believe it was Professor Lamb, of Owens College, Manchester, who described the subject of Applied Mathematics as the application of mathematics to something to which mathematics could not be applied. The inner meaning of this description is well illustrated in the attempts which are being made to apply mathematics to geared drives. In Engineering of September 8, 1922 (page 290), Mr. Albert Eagle challenges the conclusions which I placed on record at the Spring Meeting of the Institution of Naval Architects. In replying to this article, it appears to me better for all concerned to take a survey of a few aspects of the vexed question of geared drives.

The difference between my published investigation and that published by Mr. Eagle is a very simple one. We have really been working together along the same street. He boldly attempts to apply mathematics to the case in which frictional terms are included, whilst I have been satisfied to consider the worst possible form from the engineering point of view—that is, the case in which friction is neglected. We work on different lines; he is forced to assume a frictional constant and apparently a simplification of the drive, whilst I take every suspicion of a critical state of vibration as a "possible" danger zone. So far, then, it is, I hope, quite clear; we only differ in the assumptions we make. We will assume that in both cases the mathematical work is accurate. He does not challenge mine; I do not challenge his.

It remains for us to compare not only the assumptions made but also the two sets of conclusions arrived at, and test whether they agree with actual experience. Keeping in view my opening statement, the method of attack matters little. The question is one causing anxiety to engineers, and the object of the work is to evolve reliable rules for the design of geared drives. If we reason on different lines and arrive at the same results it is fairly safe to say that, although we have agreed to differ, we have probably helped to establish firmly some points about which there has previously been doubt.

I will deal with the most important point in Mr. Eagle's paper. So far as I read, he maintains that parting of teeth, or the establishment of forces which might damage the teeth, owing to propeller blade disturbances is practically impossible in all cases ranging from the short-shaft oil tanker to the long-shaft liner. The short-shaft arrangement, according to my reading of his paper, gives a better result than the long shaft. His figures for two cases in which the length of the tunnel shaft only is changed are :—

Length.	Magnification factor.
35 ft.	1·48
98·5 ft.	3 to 5

I wish to be careful on this point because I myself have only dealt with cases where the tunnel shaft lengths have been between 140 ft. and 250 ft.

Mr. Eagle, then, has proved that parting or excessive pressure is impossible. We can easily find out whether this conclusion agrees with actual experience. A simple question then arises. Did parting or excessive pressure ever occur at the period of the propeller blade beats? I am afraid I must write down the answer to this in the affirmative.

There are different kinds of parting, varying from the touch-and-come-again, which must always occur at high periodicities, through all the rumbling big drum effects up to the sledge and pneumatic hammer blows, jumbling unharmoniously in the roar of a bad example. Messrs. Walker and Cook discuss two examples in which excessive pressures were met with—the San Florentino and the San Fernando. In these cases "indications were observed of excessive pressure at definite angular positions around the gear wheel." These, I take it, are two cases in which parting occurred. Surely Mr. Eagle does not wish to infer that these two gentlemen did not secure a cure. I need not pass beyond the region of my own experience. It appears to be assumed that if big drum effects are in evidence at the propeller blade periodicity, Mr. Eagle explains them on the assumption that the periodic tooth inequalities correspond to the propeller beats. Such conditions would be extraordinary coincidences.

In experimenting on various ships Mr. Wilkie and I have had many interesting experiences. In one ship we were not able to obtain a critical speed. It is only fair to explain that we had not attempted a thorough investigation. It will be understood that in forced vibration it takes some time to reach a steady state. Mr. Wilkie chaffed me very badly, maintaining that in this case there were no critical speeds, but, when finishing the extended trials and on entering Liverpool at 1 a.m. on January 13, 1922, a rumbling and banging was heard in the engineroom. The speed of the machinery was raised and lowered several times and a critical speed range was determined. Without readings such as these the subject is Applied Mathematics. When these are obtained and analysed the subject changes its character and we begin to study engineering technology.

Before leaving this point I should like Mr. Eagle to read the two paragraphs of my paper immediately preceding the section on the critical speed diagram. He will then see that we are in close agreement. The only point is that I do not clearly state how these high-periodicity criticals arise, whether from the propeller, the teeth, or the eddies in the turbines. The critical speed diagram is argued out on propeller beats because we have something tangible there to speak of, but unworkable ranges exist for periodic tooth irregularities.

The misunderstanding with regard to technological work is at least amusing; many people have the idea that investigations are carried out in a few minutes, and that the investigator never worries about checking as to whether his results will stand the test or not. As a matter of fact, the work extends over a very long period and all kinds of side tracks are probed for information.

The peculiarity of tooth scouring was first impressed on my mind in 1907, whilst developing a fatigue-testing machine. A slight reference to this will be found in a short paper published in Engineering, July 23, 1909. This date can be put down as the real starting point of my geared-drive investigations. It was from these experiments that I deduced that the high-periodicity criticals are the cause of the pneumatic hammer effects and are the most serious.

Applied mathematics is an extraordinary subject, and we can forgive the average engineer for having little confidence in deductions made by its help. He cannot afford to wait 14 or 15 years for a little light; he must deliver the goods. The engineer is very sensitive about his own chickens. This article shows that. The extraordinary conditions operating the minds of engineers are well illustrated by some of my own personal experiences. When the mathematical work relating to the paper on "Nodal Arrangement of Geared Drives" was in the stage in which it was published, I was put in touch with a number of engineers who should have known the real state of affairs. I was not out to reveal to them all that was in my mind for the "chicken" reason mentioned above, but I was particularly anxious to know how things really stood in the running of geared drives. Now, my applied mathematics has led me into a most extraordinary position. If I had any confidence in my conclusions, the geared drive as at present contrived seemed an extraordinary proposition, for I well knew from my experience of 1907 that if one of the high-periodicity criticals were established in any of the existing drives, the apparatus could not last many hours. So I had not the confidence in critical speeds which Mr. Eagle assumes me to have. Still, the chance of clashes was tremendous, and the point could only be settled by an inquiry into the actual experience of engineers. However, by those who knew, or should have known, I was told that everything was in a highly satisfactory state, and that the designed arrangements led to a reliable job. Naturally, if this were true, the only explanation that could be given of the peculiar behaviour of the ss. Melmore Head was that she was a bewitched ship. I was not out to accept this kind of thing. I do not believe in supernatural things. It is true many were grumbling that things were not satisfactory and certain individuals were very excited. The question to be solved was very simple. Apparently it was one in psychological mathematics, namely, to add together zero and infinity and by dividing by two to attempt to obtain a rough mean. It is very similar to one which faces most of us at the present time, when we begin to be original on the subject of international finance.

I gave this up and put the rough manuscript of my paper away for twelve months and waited patiently for a little more light. During this twelve months a most distressing state of affairs developed, and I was thoroughly convinced that the conditions were bad and that my predictions had to a certain extent been in the direction of approximating to the truth.

A few months after the publication of the paper referred to I visited the engineers of about twenty shipping companies who had geared drives in operation. One of the primary objects of my visits was to gather reliable information as to how matters stood. The result of these visits was a surprise to me. I found no enthusiasts, but many pessimists, and the latter had ample reasons for being so. Before proceeding further I desire to place on record my sincere thanks to these engineers for their kindness and for their candid expression of opinion.

I may not give details of the visits, but I trust and believe that, for the common good, these engineers will not object to my deducing from our conversations the outstanding points of general interest. I find that engineers who have actual experience with reduction gearing may be divided into two classes as follows :—(1) Those who have geared ships which have given very little trouble, and (2) those who have geared ships which have given serious trouble. Practically all engineers of Class 1 condemn the geared arrangement as uneconomical and say that they await results "touching wood." Most engineers of Group 2 look upon the geared drive as an economical proposition and are anxious to make it a mechanical success.

There is, of course, some doubt in a classification of this kind. One meets an occasional strong character of the old school who resents the intrusions of an enquirer, and will not express any opinion on our subject, but has very pronounced opinions on something which does not bear directly on the problem. The remarks in this case are not very helpful. This seems to be the state of affairs. I have no reason to doubt the extreme candour of the many engineers with whom I conversed on the subject. I shall look back on these visits with pleasure, as I learnt a great deal more from them than I can ever hope to return as a free lance in engineering technology.

In the paper on "Nodal Arrangements of Geared Drives" read before the Institute of Naval Architects in April last, there are two statements which to the reader may seem extraordinary. The first one appears at the end of the preface; the other precedes the last sentence of the paper. These statements were not made in a casual way, they were deliberately inserted in order to bring matters to a head. I remember the time when one of my colleagues, after reading the proof of the paper,

came back with the remark that it contained too many "possibles" (possible number of critical speeds), and that I might vary the language a little with advantage by using a few probables. No probables were introduced, however, because the word possible gave the real meaning I wished to convey. Now, a few readers, including Mr. Eagle, have apparently misunderstood the meaning of the word "possible" and have taken it to mean "actual." If all the "possibles" were changed to "actuals" the picture painted in the paper would be tragic in the extreme. The critical speed diagram would in the general case consist of four or five horizontal lines and 100,000 sloping lines.

To prevent any further misunderstanding, I would like to mention that the really important points in the paper are the conclusions arrived at. There are seven of these at the beginning of the section which deals with the simplification of geared drives. The method of arriving at the results given in the paper is not the only method which I have tried. The subject had to be checked in all the ways I could devise before I published the results. These seven conclusions are followed by a sentence of a kind similar to those mentioned above. These conclusions are again written deliberately, and it is the affair of my critics to upset them if they can. The line of attack does not really matter. It is far better to attack the problem in a different way. The test will be in all cases a comparison of the conclusions arrived at in conjunction with the assumption made. I can scarcely hope to be accurate in all details, for the subject is very complex—far more so than any of my critics imagine. My applied mathematics may be faulty—such work must always be so. We may take any of the applications of mathematics to technological work and we find the work is nearly always faulty. If we ignore this point and are determined to take into consideration every side track we arrive at nothing. When I wrote in the preface that "I would attempt to take into consideration all possible factors, &c.," my meaning should have been clear, namely, all factors which I could handle with my mathematical knowledge.

In the discussion I remarked to one of my critics who had laboured the point relating to frictional effects being neglected, that if he could solve the problem, taking into consideration friction, I would wish to be the first to congratulate him on his success. Now, Mr. Eagle has boldly attacked this problem, and although, through neglecting the elasticities of the turbine shafts, he has avoided the higher criticals, I admire his pluck, but must challenge his conclusions.

In dealing with this work I would like to point out the effects of small differences, and I cannot illustrate my point better than by dealing with a classical example, which must finally have a direct bearing on this work. I refer to the work of Professor Osborne Reynolds, under whom I had the honour of working for seven years. Professor Reynolds settled for all time the difference in the frictional constant for the two kinds of flow of liquids—stream line and sinuous. His famous experiment decided a question at stake for a long time. The differences of the physicists and engineers were explained. Now, Mr. Eagle quite neatly introduces a constant of from 2 to 4 as the index of the frictional term in his paper. I do not object to this, I simply point out that he had to assume some value, and that in doing this he might possibly make a grave error unless his value is chosen as a result of analysis of some experimental work. One might speculate for weeks on this question of the index to be used in the frictional term for a propeller's vibration and not make any progress. The artistic part of technological work is always that of starting to reason or experiment where the last man left off, but one cannot do that here because there does not appear to have been any reasoning or experimenting on the damping of the small oscillations of propellers. The determination of this quantity does not appear to be by any means simple, as one of my colleagues who has tried it can certify. It would form the subject of an interesting research and should be attempted. The analysis of trial results can, of course, be attempted, but, if the original mathematical analysis is faulty, such a method of procedure is impossible. We will say, however, that the best of a bad bargain has been made as regards this frictional constant.

Having done this, the differential equations are built up. Let us examine what has been done in building up these equations. We will not say that Mr. Eagle is wrong in doing this, but we must not pass it over without comment. It will be observed that he has neglected the elasticities of the turbine shafts and collected the whole inertia apart from the propeller, at the gear box. The differential equations are thus built up for a simple system consisting of the propeller, its shaft and a second mass. His chosen system then consists of a simple shaft with two masses attached to it. By reducing the system in this manner he would appear to have cut out altogether the possibility of any high-periodicity effects. The main point which I was in search of was high-periodicity effects, for, as I state in my paper, a low-periodicity effect, if properly placed, can in any case be avoided. Mr. Eagle obtains a solution of the differential equations in the shortest possible way by means of very neat and established methods. He very cleverly analyses the results obtained and shows, as before mentioned, that parting is impossible. The remarks of some other critics are more valuable than the deductions by Mr. Eagle so far, since they have, without making any assumptions as to the frictional constant and mass concentration, actually measured with a torsion meter the torque fluctuation when slowly passing through a critical speed in an actual drive. This is the point at which we part company, even if the teeth of his assumed system do not. His argument now takes the line that the tooth pressure torque can never exceed in semi-amplitude the transmitted torque, and, therefore, that parting is out of the question. I think it is Taylor who points out that there are two sides to everything in this world, including propeller blades. We must not forget that this is very true when we pass the main gear wheel of a geared drive in the direction of turbines. There may be more, but I have never met with less than two.

Assuming his result to be accurate, let us consider how the fluctuating torque is distributed in the turbine shafts. We need not trouble about extreme accuracy. His object, as I read it, is to show that the semi-amplitude of the fluctuations of propeller shaft torque can never exceed the transmitted torque. It is only fair to mention that he does not state this precisely, but I can only take it this way.

In an example with which I am amusing myself at the present time the moments of inertia for the two sides are as follows :—

$$I\,lp = 18{\cdot}7 \times 10^6\,;\; I\,hp + I\,ip = 2{\cdot}3 \times 10^6.$$

Now, suppose we take an extreme case, where the moment of inertia on one side (*hp* and *ip*) is negligible. In such a case the whole effect of torque fluctuation is doubled and his factor is increased 100 per cent.

The conditions are, of course, not quite so bad as that for the inertias I give above, but the whole torque variation is in this case (if the system has stiff turbine shafts) divided into 0·89 on the *lp* side and 0·11 on the other side. The *lp* side then breaks down first, if parting occurs, and when one side breaks down we have oblivion as regards calculation.

Following up the matter on the lines indicated, the magnification factors allowable before parting occurs are roughly as follows :—

A	Per cent. torque variation	10	20	30
	Magnification factor ...	5·6	2·8	1·85

The actual values for this quantity mentioned by various individuals in the discussion of my paper are 10, 4·5 and 4, so that from this point of view the question of parting of teeth in the particular machinery with which I am dealing cannot be written down as impossible. It will be understood, I hope, that I am taking a broad survey of this complex subject.

The question which naturally arises is, what kind of system has Mr. Eagle assumed in order to get his most interesting result. He throws no light on this in his paper, but is quite satisfied to leave his neat piece of mathematical work in an unfinished state. Let us examine in detail what is really behind all this. If my contentions are correct, the elements which Mr. Eagle is considering must be friends of the kind I have been looking for. I welcome his criticisms of my conclusions, and in return I am sure he will not object to my deducing something from his.

In the best arrangement of a geared drive of the kind with which we are now concerned, the masses, &c., must be so contrived that, if parting does occur, it will occur on the two sides simultaneously. In such a case the torque variation will be equally distributed on the two sides and will be the least possible torque variation which can be obtained. This is the arrangement upon which Mr. Eagle bases his reasoning. The allowable magnification factors in this case are, of course, much greater than in the preceding case. They are as follows :

B	Torque variation ...	10	20	30
	Magnification factor ...	10	5	3·3

In order that there may be no doubt about these values in the two cases, we may compare them in a slightly different way as follows :—

Comparison of Total Torque Variation Allowable in Two Geared Drives.

Per cent. total torque variation at limit for hap-hazard case dealt with in A	56
Per cent. total torque variation at limit for arrangement B, in which both sides break down together	100

What Mr. Eagle has done now becomes fairly clear. He has assumed that parting occurs on the two sides simultaneously and that 100 per cent. variation is required to produce it, whereas a total variation of 56 per cent. is sufficient to cause parting.

Most people reason on this line, so that it is advisable to point out what they have assumed when they do this. It is an important point, because it is not revealed by a torsion meter when readings are taken passing through the resonance range.

In order to get simultaneous breakdown on the two sides it should be evident that the masses connected to the two sides must be equal (dynamically), and that the elasticities of the two turbine shafts must also be equal. These are conditions required for the maximum allowable torque variation, and these are the conditions which Mr. Eagle has unconsciously assumed to hold for his drive. Mr. Eagle has, then, balanced his turbine masses, and when later he speaks of elastic turbine shafts he has tuned his shafts. In fact, Mr. Eagle has been dealing with a nodal arrangement. He has incorporated the whole of No. 3 item of my scheme of simplification. This item is as follows :—(3) Making the elasticities and masses of certain shafts dynamically similar.

The next point I would like to deal with is that referring to tooth irregularities. In my investigations I find that any periodic irregularity searches the free periods of the system and leads to certain critical speed ranges. It is absolutely impossible for any arrangement to smooth off the effects of these. In the discussion I mention that the only way to study these is to consider the motion of the wheels in pairs. The measurement of the pitch variations of a wheel is, in my opinion, not completely satisfactory.

The values of the torques arising from periodic tooth irregularities are easily calculated from the equations given in the paper; the mathematical results are found to be precisely similar to those which appear under the head of external disturbance effects, except that there is a higher and longer critical speed range extending from some high periodicity to an infinite periodicity.

Mr. Eagle says that I do not consider the effect of tooth irregularities in my paper. On this point he is quite mistaken, and I must ask him to refer to the paper. He then assumes that he himself considers tooth irregularities. Any reader will see that he has pushed through the work very quickly without any symbols and is in a great hurry to arrive at some sweeping conclusion. This conclusion is so important that it is recorded in italics. There is no evidence of any reasoning to support this conclusion. I simply mention this, of course, in order to prevent any misunderstanding.

Perhaps the most extraordinary item in his paper is to be found in his statement that his conclusions are diametrically opposed to mine. There are at the present time five complete nodal arrangements and one partial nodal arrangement working in ships at sea. Mr. Eagle can examine any one of these if he will take the trouble to do so, and he will find "that such turbine pinion is connected to its turbine by as flexible a shaft as the torque to be transmitted and the available length at our disposal allow." These words should be compared with Mr. Eagle's conclusion, and the drawings of the arrangement used in the ss. Melmore Head should be examined.

In five out of the six cases mentioned above the restriction in length, apart from certain lengths fixed by calculation, has been caused by a bulkhead, for, although length could have been obtained by passing the shaft through the turbine rotor, our experience with nodal shafts has made us reluctant to design arrangements of that kind.

Mr. Eagle's italicised conclusion cannot, then, be new when we have been working on these lines. The conclusion is simply No. 5 of my paper on "Nodal Arrangement of Geared Drives" differently worded. It is as follows :—(5) Attempting the elimination of high-periodicity disturbance by lowering the pitch of the possible free vibrations. In the word "disturbance" is included propeller effect, eddy or blading effect in turbine, and periodic tooth irregularity effect.

It appears to me, then, Mr. Eagle discovers nothing by direct analysis. His chief result is of a negative nature. His system is not the haphazard system at present in use, but a system consisting of two masses attached to an elastic shaft which bears no resemblance to the existing arrangement of geared drives. When he reasons on tooth separation he appears to assume a nodal arrangement and to claim all the advantages of such. Instead of attacking the mathematics of tooth irregularities himself he accuses me of not having done so, clearly showing that he has not read my paper. Then he finishes with a statement that his results are diametrically opposed to mine and attempts to make this clear by the only piece of constructive criticism in the paper, in which he quotes one item from my suggested scheme of simplification with a slight change in the wording, a point which is already incorporated in six ships at the present time.

In conclusion, I may say that I admire Mr. Eagle's bold attack. I appreciate fully the difficulties to be faced, and, if in any of my remarks I appear to be a little rough, I desire to state with all sincerity that I have no intention in that direction. Many of the existing geared ships are behaving in a doubtful fashion, and, if the problem is going to be solved without replacing the turbines by reciprocating engines, the time has arrived when all who are interested should remove the gloves and fight out every feature of the problem. The most interesting feature of Mr. Eagle's paper to my mind is the fact that he is the first critic who fully recognises the importance of my proposal for giving ample torsional elasticity to geared drives. It is, in my opinion, by the introduction of torsional elasticity that the first benefits will be felt, but with its introduction I am led to believe that the clearly-defined oscillation systems which will be introduced may be exceedingly dangerous unless the other factors which I place on record are carefully considered.

J. H. SMITH.

Municipal College of Technology, Belfast.
October 3, 1922.

"THE ECONOMICS OF MAIN LINE ELECTRIFICATION."

TO THE EDITOR OF ENGINEERING.

SIR,—I have read with interest the article which appeared in the issue of your Journal for May 12, page 592, dealing with the paper read by Mr. R. T. Smith, before the Institute of Transport, on the economic electrification of main railway lines.

In his paper, Mr. Smith very rightly showed the great interest which attaches to the development of electric transmission by high-tension continuous current; he also referred to objections made to the generally well-known Thury system, and to advantages resulting from the use of current rectifying machines, called "transverters" due to Messrs. W. E. Highfield and J. E. Calverley.

Mr. Smith was doubtless unaware that Sécheron Works, formerly Compagnie de l'Industrie Electrique et Mécanique (Thury, Patents), Geneva, which, from the first, have specialised in the "series" system, have carried out important developments, thanks to which the few objections which might have been made to the "series" system have now been eliminated.

There is no longer any difficulty in generating heavy high-tension continuous current, and the Sécheron Works are in a position to carry out current transmission

at 300,000 volts, 300 amperes by one single line, with 12,000 kw. units, each consisting of two double machines at 10,000 volts per commutator.

In regard to the line losses, these are reduced materially at low loads by arranging that the current intensity is a function of the load.

For example, the current can be automatically doubled between no load and full load. It is interesting to note that when the amperes fall the efficiency of the continuous current series machines increases, contrarily to what obtains with alternators. The total efficiency, therefore, remains high, even at low loads.

As early as 1897 the Compagnie de l'Industrie Electrique considered the question of the production of high-tension continuous current by the rectification of three-phase current.

In 1900 they built a machine intended for insulation tests of installation, lines and cables on the "series" system, and not for power transmission at constant tension; the inconvenience of rotating brushes, together with the difficulties and complications surrounding the arrangement generally, would have rendered the matter an impossible one for that purpose at the time.

The Siemens-Schukert Werke have also found out the incontestible inconvenience of rotating brushes, and for many years they have built their synchronous rectifier for low tensions with fixed brushes and revolving commutators.

For high tensions it is necessary to revert to rotating brushes to eliminate complications. Moreover, as is the case with the "series" machines, it is necessary to connect several commutators in series in order to obtain the very high tension necessary for the power transmission, and this placing in series of the transverter commutators, which has been known for a long time, is the feature of the scheme put forward by Mr. Highfield.

As showing the progress made of late years with the series system, the few following particulars of the latest extension of high-tension continuous current transmission on the Moutiers-Lyons line in France, will be found interesting. The line is about 200 km. (124 miles) in length. The maximum tension up to the present has been 100,000 volts with a 150 ampere current. In the very near future this tension will be increased, since the Société Générale de Force et Lumière, Grenoble, who are most highly satisfied with their "series" transport system, are now further extending it.

The last machines built have been in constant service since 1911. These are double machines, of 5,000 volts per commutator with a 150-ampere current. Their speed is 428 r.p.m. Their new machines, now being built, have three commutators in series, each of 7,500 volts and 150 amperes. Their speed is 500 revolutions.

Since objections have been made to the "series" system, objections which at the present time no longer exist, it may be interesting to note some of its numerous advantages.

The possibility of reaching the highest voltages without any transformation.

High efficiency, since for equal power conditions, the efficiency of the series machines equals that of the best modern alternators.

In the loop which the series circuit forms it is possible to add generating or receiving units in any convenient order without having to consider the question of drop of line voltage.

The high-tension continuous current being transformed at the receiving station into three-phase current, or low-tension continuous current, by means of rotary sets, without any reversers, the tension at which the current is distributed to the customers is independent of the voltage drop in the line transmitting the energy.

The sudden variations in load at the transforming station are converted into slow variations in the "series" transmission, owing to the rotating weights of the transformer sets.

The extreme simplicity of the service, since the brushes do not revolve round the commutators, and since the apparatus has never to interrupt the high-tension continuous current.

The extreme simplicity of the operation of starting and stopping a set of machines.

Perfect commutation at the commutator, the commutation field adjusting itself automatically and instantly, owing to the slow variations in the line current.

The absence of all complicated switch gear, each machine being equipped with its automatic regulator, cut-out switch, voltmeter and ammeter, which constitute the whole outfit of the system.

It may, finally, be said that the "series" system has proved its value commercially and technically in the Moutiers-Lyons installation; this installation has shown that, by embodying in the new machines to be built the improvements which are contemplated, electric power transmission by continuous current on the "series" system will give every security, whilst being much more economical than other systems especially in the matter of power transmission by cable.

Thanking you in anticipation for kindly placing the above before your readers,

I am, yours faithfully,

C. Belli.

7, Rue du Mont-Blanc, Geneva.

[This letter as received by us was in French. The above is our translation.—Ed. E.]

"EVAPORATION AND DISTILLATION."

To the Editor of Engineering.

Sir,—I thank Mr. Liversedge for his letter, published on page 438 of your issue of October 6, and acknowledge *l'amende honorable* with considerable pleasure. Your correspondent raises three further points: (1) Pressure in the heating chamber; (2) probable unreliability of test results and (3) the suggestion that the plant is not in general use, although my quoted test results were dated 1914.

I have stated in my letter dated 3rd inst., that the mean temperature drop is 4 deg. C. in the particular case under consideration. In these circumstances the difference in pressure between the uncompressed vapour and the compressed mixture is therefore 2·2 lb. per square inch. Allowance must further be made for the small contributory source of distilled water furnished by the preheater condensate, this vessel being heated by uncompressed vapour as set out in my letter in your issue of the 22nd ultimo. Making these corrections and going through his figures again your correspondent will agree that suitable margin for unavoidable losses exists, and that the necessity for assuming misunderstood test conditions disappears.

The calibration of the thermo-compressor in our laboratories renders it impossible for the plant after delivery to exceed the designed consumption, and exact figures of performance can be obtained at any time without stopping or interfering with the normal running of the plant. As a matter of fact the results quoted fall considerably short of what can be obtained by the use of the thermo-compressor, and were merely given, in answer to Professor Hinchley, to show that as far back as 1914 heat pump evaporators were superior in efficiency to quadruple effect evaporators of the ordinary type.

In respect of the plant not being in general use I have dealt with the Continental position in my last letter, and the English company, although only constituted in 1920 due to the intervention of the war, is well satisfied with the results already attained. It may be of interest to add that the tentative arrangements for an independent test suggested in my last letter have been ratified, and it is hoped they will be found of sufficient interest for insertion in your columns at an early date.

Yours faithfully,

Jas. B. Maclean.

2, Central Buildings, Westminster, S.W. 1.
October 11, 1922.

"INDUSTRIAL ADMINISTRATION."

To the Editor of Engineering.

Sir,—I have read with considerable interest the leader in your issue of the 13th inst., entitled "Industrial Administration," and I can assure you that the Board of Management of the Institute of Industrial Administration heartily welcomes suggestions which will enable it effectively to aid industry in this country in the particular sphere within its aims and objects.

The need for the formulation of strict definitions in relation to the terms in use in connection with administration is fully appreciated by my colleagues on the Board of Management: of the urgency for dealing with this item of our programme, I have personally no doubt. In order that the misconception, which may have arisen, as to what, in the view of my colleagues, constitutes an "industrial administrator" may at once be removed, I feel I ought without any delay to explain that the interpretation placed by my Board on that term coincides exactly with that of the "majority" to whom reference is made in your article. The Institute accordingly does accept the view that "the great business men of this country" controlling factories are "industrial administrators"; but its governing body is of opinion that administration is not confined to the high places but permeates throughout an organisation reaching down and including even those in the grade of a foreman.

I fancy that in dealing with Captain Sankey's definition of an owner, an important qualification in the language used may have been overlooked. Captain Sankey said that the owner is "*generally passive*" (my italics). This, of course, is true; the case of the owner who takes an active part in running the undertaking in which he has invested capital was not touched upon. In the latter case the owner unquestionably ranks as an administrative officer, and the part of the annual profits which he draws out of the business really represents his salary; a fact which is, in many cases, now wisely recognised by entering the name of such an owner on the salary list with that of the other administrative officers of the undertaking.

I may say that my Board also recognises that the technical side of the work in an industrial enterprise cannot be divorced from the administrative side; but it feels that although considerable attention has been given to his technical education, the administrative side of a technician's training has not been sufficiently attended to. It was mainly to remedy this defect that the Institute of Industrial Administration was brought into existence.

Yours faithfully,

W. A. J. O'Meard,
Chairman, Board of Management.

110, Victoria-street, Westminster, London, S.W. 1,
October 16, 1922.

"STRENGTH OF RAILWAY BRIDGES."

To the Editor of Engineering.

Sir,—With reference to this correspondence, Mr. Lewis seems to consider designs by bridge contractors superior to those made by the designing staffs of our railways. While in no way wishing to belittle the work done by contractors' staffs, I would point out that railway companies are the biggest users of bridges, and all bridge designers should have experience of maintenance work. The experience so gained would not of necessity be of great use in competitive designs, but first cost need not be the truest economy. There are so many things in design to be avoided, and adopted, that can only be properly realised after experience in maintenance.

I still think the probability of serious impact stresses in railway underbridges is remote, in the sense that a suddenly applied load produces twice the stress a static load does, as enunciated in most text books on mechanics.

A load rolling on to a bridge causes the stresses in the bridge to gradually increase and decrease. Admitted that there will be shock with sleepers requiring packing, and rail joints, but this is greater in the minds of many than in fact, and nothing near so great as an iron tyred motor vehicle staggering on a pot-holed surface perchance mounting a loose stone and crushing it.

It is to the locomotive we must look to explain the stresses in a railway bridge. The rotating parts of a locomotive may be balanced, the reciprocating parts cannot wholly be balanced, and yet the only information usually supplied is a diagram of axle loads and spacing, whereas the reaction of a locomotive travelling at a high speed on a bridge is probably nothing like what the diagram would lead one to suppose, owing to the effect of the reciprocating and rotating parts, this may be "impact," but it is not caused by the mere movement across a bridge of the axle weights as given by the diagram. How far locomotive engineers know by calculation and experiment what these loads may be, and how far they are willing to divulge the same, I do not know, but the writer would like to know if there is any published information on this point.

While methods of computing stresses have become more refined, not enough research has of recent years been done, and until it is done, theory as at present applied, and experimental results will not agree as they should do, and under these circumstances the rules which Mr. Lewis cries out for cannot very well be formulated.

Yours faithfully,

Frank Tiffany, B.Sc., Assoc.M.Inst.C.E.

Bridge House, North Rigton, Huby, Leeds,
October 16, 1922.

"THE APPLICATION OF OSCILLATING VALVE CURRENTS TO THE MEASUREMENT OF DIELECTRIC CONSTANTS AND MAGNETIC SUSCEPTIBILITIES."

To the Editor of Engineering.

Sir,—I wish to take this opportunity of correcting your report in your issue of September 29, page 390, of my paper before Section A of the British Association, Hull, 1922. In the paper, I explained that the applicability of the simple formula for the frequency of a valve circuit $\left(N = \frac{1}{2\pi\sqrt{LC}}\right)$ had been fully investigated for low frequency oscillations by the use of standard tuning forks, and for high frequency oscillations by means of a standard wave-meter. It was shown that if C is the capacity of the circuit introduced by the condenser (measured electrostatically), N^2C decreases as the frequency increases, but that by the suitable choice of a quantity c, $N^2(C + c)$ is constant over a wide range of frequencies. The introduction of c indicates that the capacity in the formula for the frequency must include not only that introduced by the condenser, but the capacity of all the component parts of the circuit together with any change in the value of the capacity due to the use of high frequency fields.

For the measurement of low order susceptibilities, I made use of a horizontal parallel plate condenser, the upper plate of which was clamped to a vertical upright fixed rigidly to a steel base, while the lower was fastened to a long brass rod and suspended by means of a thin steel horizontal wire, under tension, between two vertical uprights fixed to the same steel base. The lower plate was thus free to move in a vertical plane, the motion being controlled by the torsion of the wire. The apparatus is essentially a delicate torsion balance, and the feature of the method is that the determination of the additional tension P requires no troublesome balancing, the measurement of the change in frequency of the circuit of which the condenser forms a part, alone being necessary.

Yours faithfully,

J. E. P. Wagstaff.

The University, Leeds, October 13, 1922.

The Institution of Electrical Engineers.—The opening meeting of the Institution of Electrical Engineers will take place on November 2, 1922, when Mr. Frank Gill will deliver his inaugural address as president. This will be followed by an ordinary meeting on November 16, when a paper by the late Dr. G. Kapp, on "Phase Advancing" will be read by Professor Miles Walker. The Wireless Section will commence its meetings on November 8, with a paper by Messrs. R. L. Smith-Rose and R. H. Barfield on "The Effect of Local Conditions on Radio Direction-finding Installations." The annual dinner of the Institution will be held on Tuesday, February 6, 1923, at the Hotel Cecil.

Manchester Metallurgical Society.—On October 10, at the Manchester College of Technology, Mr. W. Webster Wilson delivered his presidential address before the Manchester Metallurgical Society. Mr. Wilson emphasised the unique opportunity which present conditions afforded for the intensive application of metallurgical knowledge and science. Demands for guarantees of life and service, coupled with the necessity for every possible reduction in price, made it essential for every possible use to be made of the teachings of metallurgy. Mr. Wilson referred specially to temper brittleness, and to final low temperature treatment of cold-worked steels for elastic development, and stated that, in view of the effects produced, final low-temperature treatment should be restricted to fields which were fully explored.

THE STRUCTURE OF EUTECTICS.*

By F. L. BRADY M.Sc. (Birmingham University).

(*Concluded from page* 477.)

The Coalescence of Eutectics.—The coalescence of pearlite has been referred to. It is quite possible to cause the breaking up of these laminated structures into the coalesced structure, by prolonged annealing at a temperature a little below the solidification temperature, thus allowing diffusion to take place readily. This action was observed by Rosenhain and Tucker, and the experiments have been repeated.

A sample of the lead-tin eutectic was prepared and cast into a small cylindrical ingot weighing about 100 grammes. A portion of the ingot was sawn off and showed the ordinary structure free from primary dendrites. A hole $\frac{1}{12}$ in. diameter was drilled down the centre of the ingot, this size being chosen to fit closely the bulb of a mercury thermometer, reading to 200 deg. C. The metal was then placed in the small electric furnace, with the thermometer projecting through the asbestos cover. By means of resistances the temperature was kept constant for 2½ hours at a temperature near to 175 deg. C. The eutectic temperature is 183·3 deg. C.

A sample was then cut and examined. The laminæ had commenced to break down into bands of irregular thickness, broken in places. Further annealing was given for a period of 4 hours, at a temperature of 177·5 deg. C. Fig. 18 shows the alteration in structure produced by the coalescence of the lamellæ, but this structure is entirely different from the normal structure of a globular eutectic (Class 1). The particles of the lead phase are: (1) Irregularly shaped; (2) irregularly distributed. Globular eutectics show particles of the one phase which are: (1) Almost uniform in size and spherical in shape; (2) arranged in some definite pattern.

It is very significant that the coalesced eutectic of lead and tin fails to show the pearly lustre when examined with the naked eye, which the normally cooled eutectic shows. This pearly lustre is characteristic of all normal eutectics, even when the one phase is present in only a small proportion, *e.g.*, silver-bismuth, gold-bismuth, and also of the normal globular eutectics, *e.g.*, tin-cadmium, silver-copper. This fact sufficiently emphasises the abnormal nature of the structure produced by annealing.

It will be seen, therefore, that it is possible to produce in a lamellar eutectic another coalesced structure, but this structure is abnormal; all the stages in the coalescence of pearlite can be produced in the lead-tin eutectic, as has been described, and this points to the similarity in the causes at work. The structure shown in Fig. 18 can also be produced by very slow cooling, which also is productive of an annealing effect, and this shows how necessary it is in the examination of eutectics for purposes of research to use a rate of cooling which is not too slow, as very slow cooling produces merely an irregular aggregate of the two phases, in which the original structure produced during solidification has been removed by the annealing effect which has proceeded subsequently. In all cases examined for the purpose of classification cooling has proceeded at a rate similar to that obtained in taking a normal cooling curve in pyrometric work.

Eutectics are sometimes loosely regarded as being all "pearlitic" in structure, or sometimes as "lamellar," and it is worthy of note that close analysis of the eutectic structure has so far only indicated one alloy, in which the whole structure is lamellar in character, or similar to normally cooled pearlite.

Class 3—*Angular.*—This class includes the largest number of eutectics, and includes the greatest variety of structure amongst the individual alloys of the class; but in spite of this variety of structure the similarity in the main respects of the forces acting can clearly be seen in every case. It has already been indicated that there are two divisions in this class.

The first division includes eutectics containing at least one metal of low surface tension, *e.g.*, antimony. The form of any solidified homogeneous metallic crystal or dendrite can be considered as depending on the relative values of the cohesive forces (tending to produce definite crystal forms, angular dendrites, or elongated needles) and the surface forces (tending to produce forms such as rounded dendrites or other masses of rounded form). In the case of bismuth and antimony the cohesive forces are in the ascendant, the surfacial forces being small. The form of primary dendrites of bismuth or antimony is very familiar and characteristic. In eutectics containing these metals the low surface tension metal tends to assume its own crystal configuration, and this tendency manifests itself in various ways.

Fig. 19. *Antimony-Lead.*—The structure shown consists of small needles of antimony surrounded by lead. The antimony crystals are commonly arranged in a manner reminiscent of martensite, some of the needles being arranged in the form of equilateral triangles, and there seems a definite crystalline arrangement of the antimony particles. In some places these have a triangular or square shape, and must not be confused with primary dendrites, which would be very much larger. Herring-bone structures, such as those in the lead-bismuth and tin-bismuth alloys, are to be seen in some places, but are more rare, and are not included in the photomicrograph for that reason.

Figs. 20 *and* 21.—The tin-bismuth and lead-bismuth eutectics are extremely similar. It has been said in describing the lead-tin eutectic that the lamellar structure of this alloy is due to the similarity of the forces of the two metals. This similarity in properties is also shown by a comparison of the eutectics which each of these metals gives in conjunction with bismuth. There is in each case an abundance of what have been called by some "herring-bone" structures: this term only refers to the superficial appearance of the alloy, and it is probably better to use the term "dendritic" for this structure. Examination of many samples of these eutectics makes it quite evident that these forms are produced by growth analogous, if not exactly similar, to that of a primary dendrite of a pure metal. As these structures occupy almost the whole field in these eutectics, this division of eutectics may almost be called the "dendritic" type.

The work of Benedicks should be considered in this connection, and his research on the crystallisation of the white-iron eutectic may have a bearing on the nature of these eutectics, as he himself once suggested. The cementite-austenite eutectic frequently forms very interesting colonies of the two phases. He shows that the two constituents are arranged at right angles to a rod-like mass of the cementite, which plays the chief part in controlling the eutectic formation. The accurate determination of the nature of this structure was made by him by cutting two surfaces of the specimen at right angles, and comparing the structures shown on the two faces. The structures he describes are very common in eutectics containing compounds, *e.g.*, the well-known iron phosphide eutectic, and these seem to be caused by the same forces as those responsible for those in the first, or A, division of Class 3.

The similarity of the tin-bismuth and lead-bismuth eutectics to the structures in some eutectics containing

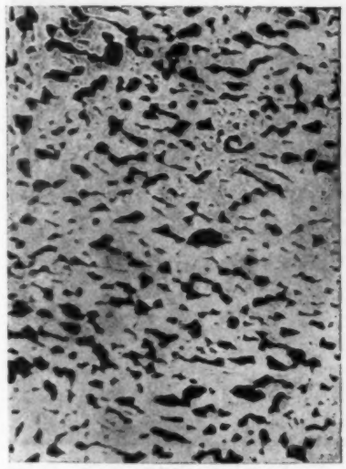


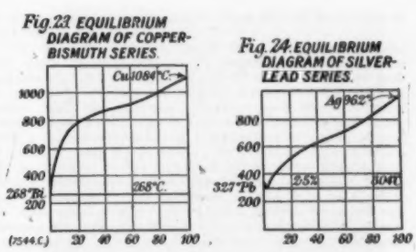
FIG. 18. Lead-tin eutectic annealed for 6 hours at 177·5 C. × 200.

FIG. 19. Antimony-lead eutectic. × 100. Etched with silver nitrate. Antimony, light.

FIG. 20. Lead-bismuth eutectic. × 200. Etched with chromic acid. Lead, dark.

FIG. 21. Tin-bismuth eutectic. × 250. Etched with alcoholic iodine. Bismuth, dark.

FIG. 22. Cadmium-bismuth eutectic. × 300. Etched with alcoholic iodine. Cadmium, dark.



* Abstract of a paper read at the meeting of the Institute of Metals, at Swansea, September 22, 1922.

the tin-antimony compound is very striking, and is mentioned as an example of the way in which this classification may be able to be extended.

Fig. 22. Cadmium-Bismuth.—A somewhat complicated structure is exhibited by the cadmium-bismuth eutectic. This might be expected from a consideration of the somewhat abnormal surface tension conditions. In this alloy bismuth, a low surface tension metal, is alloyed with a high surface tension metal, instead of, as in the previous cases, with a metal, such as tin or lead, of intermediate surface tension. The two metals are also present in similar quantities by volume. The percentage weight of cadmium is 40 per cent., but if this be converted into percentage by volume the cadmium occupies 43·2 per cent. of the alloy. As a result the cadmium and bismuth are each tending to confer high surface tension metals is the same as the order of melting points. Hence the surface tensions of these metal pairs also differ considerably.

It also follows from theoretical considerations of the effect of solution in lowering the freezing point, that when a high melting-point metal forms a eutectic with a low melting-point metal, the high melting-point metal is present only in a small proportion in the eutectic alloy, *e.g.*, silver-lead, 2·5 per cent. silver. Therefore all the eutectics in this class are produced by the solidification of a mixture of (*a*) a metal of low surface tension and low melting-point with (*b*) a small proportion of a metal of high surface tension and high melting-point.

It is also a necessity of these conditions that, since the eutectic temperature is below the melting-point of the low melting-point metal, it will be very much more below

From this phenomenon conclusions have been arrived at which are given quite clearly and concisely by Hoyt.

Taking into account the work of Tammann and others the conclusions may be stated as follows:

The tendency of a metal to give angular dendrites is proportional to its resistance F. This may be overcome by its surface tension *a*. If resistance increases more rapidly with decreasing temperature than the surface tension, there will come a point when F will be greater than *a*; angular dendrites will then be formed. (It is better to use the word "cohesion" instead of resistance, cohesion being taken to mean that force which causes material to give masses of definite crystalline outline on solidification, a sense in which the word is quite frequently used to-day.)

Tammann's work is of great importance in connection

Fig. 25. Silver dendrite in silver-lead alloy. 3·5 per cent. of silver. × 100.

Fig. 26. Lead dendrite in alloy containing 1·5 per cent. silver. × 100.

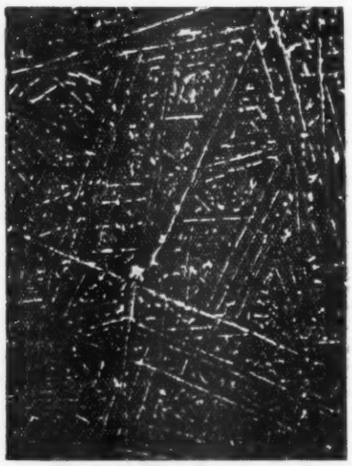


Fig. 27. Silver-lead eutectic. × 70. Etched with silver nitrate.

Fig. 28. Silver-bismuth alloy. × 70. Etched with alcoholic iodine. Silver, dark.

Fig. 29. Gold-bismuth eutectic. × 500. Gold, light.

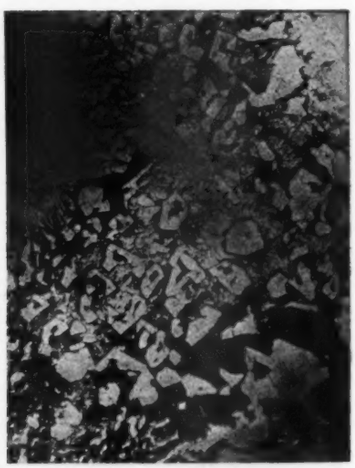


Fig. 30. Quartz-felspar eutectic. × 50. Transmitted light. Quartz, transparent.

opposite characteristics on the structure. The cadmium is tending to form into globular masses by virtue of its high surface tension. The bismuth, on the other hand, is tending to take up its usual angular crystalline formation. The two actions cannot proceed together, as it is, of course, impossible to fill space with a mixture of cubes and globules. Over the greater part of the field the structure consists of crystals of bismuth surrounded by cadmium (dark). Several fairly well-developed crystals of bismuth can be seen. Again, in places, the structure consists of globules of cadmium surrounded by bismuth; other places show intermediate structures. As the greater part of the structure of this alloy shows the angular structure, it is best considered as belonging to Class 3, A. This alloy illustrates the accuracy with which the surface tension conditions are reflected in the eutectic structure.

Class 3—Division B.—The eutectics so far discussed have been between pairs of metals, the melting points of which were similar, but a great number of eutectics are between metals of very dissimilar melting points—for example, silver-bismuth—and these alloys differ considerably from the former. All the metals of high melting point have high surface tensions, so far as determinations have been made, and the order of surface tension among

that of the high melting-point metal, so that the small proportion of the one metal in the eutectic is solidifying in the eutectic at a temperature very much removed from its normal freezing-point. It will be necessary to consider the conditions under which the high melting-point metal is solidifying.

It has been shown by Tammann that the form of a primary dendrite depends, amongst other things, on the temperature at which it solidifies from a melt. As an illustration he cites the case of the copper-bismuth alloys. The freezing-point curve of this series is a line joining the melting points of the two metals, and very concave, towards the solidus (Fig. 23). From practically all melts of copper and bismuth, copper is the first crystallising body.

As shown by the curve, from alloys containing 50 per cent. of copper, the greater part of the copper crystallises between 900 deg. and 800 deg. C. and forms the usual dendrites of rounded form; from melts rich in bismuth, on the other hand, the copper separates at a temperature near to the melting-point of bismuth, and this copper, which crystallises at low temperature, shows quite a different structure. The copper is present in very angular forms, the dendrites being no longer rounded but exhibiting striking "arrow-head" forms.

with the solidification of molten metals, but as the eutectic in the series he has referred to consists of practically pure bismuth, the results of his work are, for the purposes of this subject, more suitably referred to the silver-lead alloys in which the eutectic contains 2·5 per cent. of silver (Fig. 24).

If an alloy of silver and lead containing 3·5 per cent. of silver is allowed to solidify, the structure shows primary dendrites of silver embedded in silver-lead eutectic (Fig. 25). These dendrites have a shape exactly similar to the primary copper dendrites observed by Tammann, and can be seen in any alloy included in Class 3, B. The silver is solidifying at a temperature of about 300 deg. C., *i.e.*, nearly 650 deg. C. below its normal melting point. The effect produced by this under-cooling is great increase in cohesion, accompanied by the angular dendritic formation. The angular dendrites resemble the forms taken up by primary antimony in alloys, antimony being a low-surface tension metal, the character of which, in eutectics, has already been referred to. For comparison, it is interesting to examine the shape of a primary lead dendrite in a silver-lead alloy. Fig. 26 shows a primary lead dendrite in an alloy containing 1·5 per cent. silver. The usual rounded dendrite is seen. Comparing the two photomicrographs,

it will be expected that in the silver-lead eutectic the silver, in view of its high cohesion, will impress its own distinctive form upon the eutectic.

The silver-lead eutectic is shown in Fig. 27. The silver exists in elongated needle-like rods or laminæ, with a very definite geometrical arrangement. Perfect parallel and rectilinear structures with triangular and rectangular forms are a prominent feature; obviously the cohesive forces have overcome the surface forces, and the cohesion manifests itself not only in the shape of the silver needles but also in their crystalline arrangement. The particles of silver may be considered as the skeleton framework of a very large crystal. Examples of such eutectics are fairly common.

The photomicrographs show the similarity, in some respects, of the conditions of solidification in Classes 3, A, and 3, B; the nature of the structure being produced in the first division by the low-surface tension of one metal, and in the second division by the high cohesion of one of the metals; both conditions are productive of similar results. Considering Figs. 27 to 29, the photomicrographs are seen to bear much resemblance to one another.

The silver-lead eutectic has been described. The silver-bismuth eutectic (Fig. 28) is very similar; the same geometrical and rectilinear arrangement is seen, but the form of the individual particles is different. The surface tension conditions have caused the breaking-up of the silver rods into shorter masses, with some tendency to roundness. This is possibly due to the greater difference in surface tension between silver and bismuth than between silver and lead, which has been able to control the shape of the laminæ without affecting their arrangement. In the gold-bismuth alloy (Fig. 29) the conditions are very similar; parallelism and rectangular grouping are the salient features.

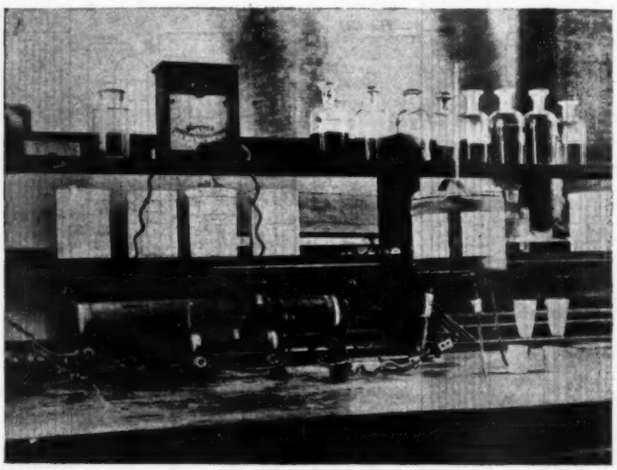


FIG. 31. The experimental furnace.

In all other cases in Class 3, B, the eutectic contains only a very small proportion of one phase. The structures are quite simple in character, the metal in small proportion is present in small arrow-shaped, star-shaped, or rod-like masses. Sometimes the phase is present as very small crystals. The structures of these alloys are as would be expected from a consideration of the conditions, but owing to the very small proportion of the one constituent they are not suitable for photographic reproduction.

Class 4—Crystalline.—This class includes eutectics between materials both of low surface tension; for reasons already stated, there are few representatives of this class in metallic alloys, and these are of little importance. This class consists merely of an aggregate of crystals of the two constituents. The eutectic between antimony and copper antimonide (a brittle compound) seems to be of this type, Fig. 7 (page 475 *ante*), though other varieties of structure are seen in this alloy. Eutectics containing compounds and brittle metals often show crystal structures. This might be expected, for metallic compounds are frequently hard, brittle substances, and, alluding to the forms which these bodies produce on solidification, Desch has remarked: "Some compounds are characterised by their sharp angles and comparative freedom from branching. Compounds $SbSn$, Fe_3P and $CuAl_2$ are of this kind."

The much larger number of eutectics which are of this class, viz., the non-metallic eutectics, will only briefly be referred to, though for the sake of completely considering the relation between surface tension and the eutectic structure some attention has been paid to them. No doubt an exhaustive examination would provide a further, probably complicated, subdivision of this class.

Non-Metallic Eutectics.—The majority of solidified non-metallic eutectics show a fine mixture of crystals, though lamellar or dendritic forms are often found. A very convenient class to study are those in igneous rocks.

Eutectics in Igneous Rocks.—Since the solidification of a mixture of two substances insoluble in the solid state will generally give rise to a eutectic, it follows that eutectics will be of very common occurrence in those natural rocks which are the result of the solidification of a molten magma, although, in view of the great tendency of many such magmas to give glasses on fairly quick cooling, the eutectic structure will only be found where the conditions have been such as to allow of the separation of the constituents in a crystalline condition. These conditions are realised in the granites, diorites and syenites, but not in the lavas and basalts. The granites are the result of the solidification of molten material at a very slow rate and under great pressure. The usual process of solidification of a rock magma is in the order of decreasing basicity—that is to say, the most basic minerals crystallise out first as definite minerals, and the more acid materials (those containing a greater proportion of silica) solidify at a lower temperature; eutectics are therefore only found in rocks containing a large proportion of silica, and the eutectic is usually between the last solidifying mineral, usually a felspar, and the excess quartz material or silica. The felspars are alumino-silicates of potash or soda.

In considering the solidification of a granite, it must be remembered that the conditions are very complex; many factors come into play, which are quite absent in the case of metallic alloys, such as great pressure. Further complications are produced by the variation in the crystal system of the materials separating. Most metals crystallise in the regular or cubic system: minerals in rocks, on the other hand, belong to various systems—quartz and felspar, for instance, belong to the hexagonal and monoclinic systems respectively, and other felspars are triclinic. This distinction also holds for other non-metallic bodies. Thus it is difficult to draw many conclusions from a comparison of igneous rocks and materials treated in the laboratory.

A specimen of granite from Finland contained the eutectic between quartz and orthoclase felspar. The structure consisted (Fig. 30) of crystals of quartz embedded in felspar crystals. The quartz crystals give triangular, rectangular, or hexagonal sections. The triangular sections are sometimes hollow; hollow squares are also common. The formation of coarser structure at the boundaries of the eutectic grain was also seen. A tertiary granite from Mull, Ireland, showed similar structures to the eutectic between antimony and copper antimonide. Some rocks examined showed a form of lamellar structure. A type of structure not found in metallic alloys is seen in those rocks which have crystallised while in a viscous condition. These rocks show spherulites, which consist of an intimate mixture of two constituents arranged in a radial manner; but these structures are not found in alloys, owing to the fact that metals do not take up a viscous condition with any method of cooling.

The rocks examined, however, showed structures which would be expected from a consideration of the nature of the constituents, and provide instances of the types of structure which are common in eutectics in non-metallic mixtures.

Summary of Section III.—The forms of eutectics, though very varied, may be divided into classes according to certain physical properties of the components. The arrangement proposed is not offered as absolute or final, but it offers a natural and comprehensive view of relations which are many sided. The division proposed shows the considerable connection that exists between the physical properties, especially surface tension, and the structure. Further study may reveal more intricate and exact relations between the various classes. If this classification and the principles on which it is based be accepted, it should provide a valuable means of comparing the properties of individual phases in other cases than those dealt with, and further extend the knowledge of the solidification of metallic mixtures from the molten state, in a field which, up to the present, has never been closely examined.

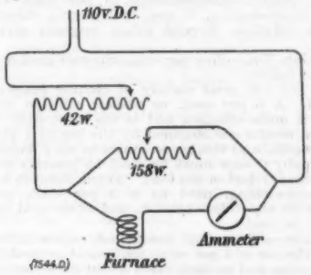
The author wished to express his thanks to Professor T. Turner, not only for suggesting this subject of research, but especially for his practical advice and suggestions during its progress; and also to other members of the Metallurgical Department of the University of Birmingham, whose helpful criticisms have been much appreciated.

APPENDIX.

EXPERIMENTAL DETAILS.

Electric Furnace.—All the alloys mentioned were melted in a small electric resistance furnace which was constructed for the purpose. It consisted of a vertical, thin-walled fireclay cylinder, round which the heating element was wound, and which was placed inside the body of a fireclay injector furnace. The thin-walled fireclay tube was moulded from equal parts of fireclay and kaolin to give plasticity, and this was baked at a high temperature. It had a thickness of $\frac{1}{4}$ in., external diameter $2\frac{1}{4}$ in., depth $3\frac{1}{2}$ in. Round this the nichrome wire for heating purposes was wound, the turns being $\frac{1}{4}$ in. apart. The wire was 20-gauge thickness. A layer of china clay was placed round the coil to keep the wire in position. The fireclay cylinder in which this was placed was 6 in. external diameter, 1 in. thickness, and 5 in. deep. The annular space, about 1 in. wide, between the two cylinders was tightly packed with asbestos wool and the top of the space closed with china clay, which helped to prevent access of air to the heated wire. A little crushed carbon was always kept at the bottom of the furnace to maintain a fairly reducing atmosphere in the furnace, and prevent oxidation of the nichrome wire. A piece of asbestos sheet was used as a lid to the furnace. The resistance of the furnace was about 10 ohms, and the passage of a current of 5 amperes was sufficient to heat it to a temperature of 1,000 deg. C.

Fig. 32. DIAGRAM OF CONNECTIONS.



The current used was taken from a lighting circuit, 110 volts direct current. To regulate the current an adjustable tubular resistance of 42 ohms resistance and a maximum current capacity of 5 amperes was used in series with the furnace. Further and more delicate control was provided by a 158-ohm adjustable resistance with a current capacity of 1 ampere, which was placed in parallel with the furnace. By altering the resistance of the branch circuit small adjustments in the furnace circuit were made. The current through the furnace was measured by an ammeter in the furnace circuit. By this arrangement the current passing through the furnace was capable of very close control, and the temperature could be kept at fairly low ranges of temperature, within a range of 2 deg. or 3 deg. C. for 6 hours without adjustment. An illustration (Fig. 31) of the furnace and a diagram of connections (Fig. 32) are given. The furnace provided a very convenient means of making up samples of alloys of about 50 grammes. Small fireclay crucibles were used for temperatures up to the melting point of silver quite regularly for a period of six months without re-winding.

Alloys would be melted and mixed rapidly, accurately and without oxidation, and a suitable rate of cooling could be given, the importance of which has been referred to.

Temperature measurement, when necessary, was made either by a nickel nichrome thermocouple and a millivoltmeter, or at temperatures below 200 deg. C. by a Centigrade mercury thermometer.

Preparation for Microscopic Examination.—The preparation of samples for microscopic examination, and especially for photography, had provided one of the most difficult parts of the work. Very little information on etching is given by some, especially by foreign, workers on the various alloy systems, and frequently the method of etching recommended, though quite suitable for revealing such a coarse structure as that of primary dendrites in a matrix of eutectic, is useless for revealing the more delicate details of the eutectic structure.

(a) *Polishing.*—A difficult feature in the metallography of many of the simple binary eutectics is provided by their extreme softness. Grinding and polishing must both be conducted with great care, otherwise sufficient surface flow and distortion may be produced to blur or alter the surface appearance.

Grinding was done on the four grades of Hubert emery-paper. This was followed by polishing with Globe metal polish on Selvyt cloth or chamois leather. This polish is usually much too scratchy for final polishing, and a finer polish is necessary. After experiment with many trade and laboratory prepared polishing powders, the most satisfactory polish was found to be a trade polish known as "Silvo." This polish apparently consists of a suspension of polishing powder in soap solution. A little of this rubbed on Selvyt cloth provides a satisfactory polishing pad for even the softest alloys.

A great advantage in the use of an aqueous suspension

is that, after polishing, the specimen is left free from grease, the complete removal of which is tedious and difficult, and etching may at once be proceeded with.

Special difficulties are provided by alloys rich in bismuth, which require specially careful treatment if the finest details of structure are to be preserved. If necessary, the final polish can be given on a Selvyt cloth which has been very slightly moistened with alcohol. If the specimen is polished on this, until the cloth is just sufficiently dry to "drag," it will generally be found that the specimen is very free from scratches.

(*b*) *Etching.*—The micro-examination of eutectics may be carried out for one of three purposes: (1) To examine the form of the eutectic crystal or grain; (2) to examine the arrangement of the phase particles; or (3) to determine the form of the individual phase particles; (2) and (3) may be called micro-etching and (1) macro-etching.

A number of samples were etched electrolytically, but equally good results were obtained by other methods. Possibly a more complete trial of the electrolytic method would have showed superiority in some special cases.

A list of the eutectics principally dealt with is given, with the etching reagents found most satisfactory. On account of the number of experiments made in some cases the list is worth recording, especially as some of the more difficult alloys have not, so far as can be ascertained, been yet opened up for microscopic examination.

Zinc-Cadmium.—Macro-etching. Saturated solution of picric acid in alcohol, or iodine solution made up of 1 gramme iodine, 5 grammes potassium iodide, 100 c.c. water.

Micro-etching. Very dilute alcoholic iodine solution, or, better, 1 per cent. solution of nitric acid in water.

Cadmium-Lead.—Alcoholic picric acid darkens the lead.

Copper-Silver.—Macro-etching, 5 per cent. chromic acid; micro-etching, 5 per cent. ferric chloride, in aqueous solution. Several other reagents give good results.

Cadmium-Tin.—Five per cent. chromic acid or dilute alcoholic iodine.

Lead-Tin.—A great variety of etching reagents can be used. A 5 per cent. or weaker solution of silver nitrate is quite effective and is the most easy to use. The best results are obtained by the use of 1 per cent. chromic acid, and this gives contrasts very suitable for photography; care must be used to prevent staining. Both reagents darken the lead. Ferric chloride is useful for macro-etching, used as a 5 per cent. solution. Ammonium molybdate solution and nitric acid solution can also be used.

Zinc-Tin.—This alloy was found rather difficult to etch. The use of 1 per cent. nitric acid in alcohol gives clear results, and etching takes about 20 seconds. The solution should be used fresh. This reagent and the following all darken the zinc: 1 per cent. ferric chloride; 4 per cent. alcoholic hydrochloric acid; 33⅓ per cent. alcoholic hydrochloric acid, used as a quick dip; 20 per cent. alcoholic nitric acid, quick dip.

Antimony-Lead and Silver-Lead.—Silver nitrate is one of the most satisfactory reagents for all alloys rich in lead, which it darkens.

Lead-Bismuth.—One per cent. chromic acid solution.

Tin-Bismuth.—Silver nitrate can be used, but dilute alcoholic iodine, about ⅓ per cent. strength, is better, and gives very clear results free from staining. It darkens the bismuth. Alcoholic iodine solution is one of the most generally useful reagents for the soft eutectic alloys.

Cadmium-Bismuth.—Dilute alcoholic iodine, darkens cadmium.

Silver-Bismuth.—This is a difficult alloy to etch, and is best treated with alcoholic iodine solution, so weak as to be only pale yellow in colour when in a bulk of about 10 c.c. If care is not taken the bismuth will stain.

Gold-Bismuth.—All methods tried were somewhat unsatisfactory. Long-continued polishing enables examination to be made. The photograph shown was of an alloy treated with many alternate light etchings with iodine followed by light polishing.

Aluminium-Tin.—Five per cent. ammonium persulphate or 5 per cent. silver nitrate solution.

Copper-Bismuth.—Silver nitrate darkens bismuth.

Copper-Lead.—Silver nitrate or iodine solution.

Zinc-Bismuth.—The chief difficulty in connection with this alloy is in polishing; in every case, after etching, the sample should be re-ground, as all etching reagents remove the zinc.

Strong ammonium persulphide is useful, but alcoholic iodine is best when carefully used, and gives the same effect as in the silver-bismuth, i.e., to leave the bismuth light and darken the other constituent.

THE MANUFACTURE OF HYDROGEN.

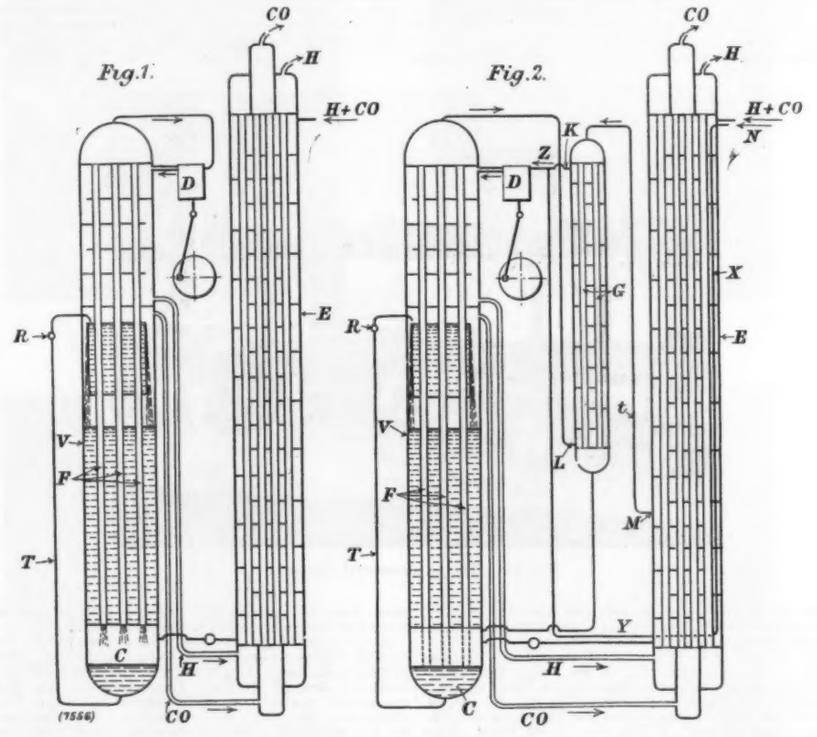
*The Manufacture of Hydrogen by the Partial Liquefaction of Water Gas and Coke Oven Gas.**

By Georges Claude, Paris.

For a number of years now I have been engaged in the manufacture of hydrogen by the partial and direct liquefaction of water gas and its analogues. For this purpose water gas, compressed to a suitable degree, is in the first instance deprived of its carbon dioxide and is dried. The gas is then sent into a heat exchanger E, Fig. 1, in which it is cooled by circulating in the opposite direction to the hydrogen and carbon monoxide which have already been separated. The gas then enters, by the collector C, the bottom of a sheaf of vertical tubes F, the lower portion of which is immersed in a bath of carbon monoxide boiling under atmospheric pressure.

By the combined influences of the pressure and of the temperature of the liquid bath a large portion of the carbon monoxide of the ascending gases is liquefied. This flows back into the collector C. Owing to the pressure this liquid is forced out through the tube T and the cock R into the vaporiser V, where it replaces the liquid which is being evaporated. The remaining gas, containing hydrogen and a little of the residual CO, continues to rise in the sheaf of tubes F. There the gases encounter a temperature which is kept very low by means which I shall presently explain. Under that influence the rest of the carbon monoxide is liquefied. Theoretically, therefore, it is a sensibly pure hydrogen which escapes from the top of the tubes, and, it is this cold and compressed hydrogen which is expanded in the device D and further cooled by this expansion to be sent back around the sheaf F, in order there to produce the very low temperatures of which I have just spoken.

In working this process two sources of inconvenience were experienced which I have only recently been able to overcome. In the first instance, when the hydrogen arrives at extremely low temperature in the expander, as indicated, the frigorific efficiency of the expansion will be very low. There is in that case a "loss" of liquid, unless we go up to pressures regrettably high from the point of view of energy expenditure. This



trouble is accentuated because none of the usual lubricants can be employed at these temperatures. Hence there is abnormal friction in the expander; this will further lower the frigorific efficiency. In the second instance, the calorific mass of the gases, leaving the tubes and afterwards the expander D and circulating about the rising gases, will be smaller than that of the latter by the whole mass of the carbon monoxide which have been liquefied by their action. As a consequence the ascending gas cannot, even assuming a perfect heat exchange to take place, leave the sheaf of tubes at the temperature at which the expanded gases enter the tubes. The final temperature of the expansion of hydrogen will, therefore, not be very low, and in addition this temperature will be badly utilised for the purification of the ascending gases.

These various troubles have been overcome in the following manner:—

1. Part of the compressed gas which enters the system is withdrawn from the heat exchanger E at a point M, Fig. 2, before it arrives in the cold portion; it is thus relatively little cooled. It is sent through the tube *t* into an auxiliary system of tubes G around which the hydrogen, leaving the tubes F and passing on to the expander, is circulated by means of the pipes L and K. This relatively warm gas will then reheat the hydrogen before it expands and this will increase the efficiency of the expansion process.

2. If we relied exclusively upon this means, the final temperature of the expansion would remain bad owing to the want of lubrication and to the eventual freezing out of the residual CO (— 206 deg. C.). We have to arrange to lubricate the machinery by a substance which will remain liquid when the temperature sinks below — 206 deg. That substance cannot be petrol, ether, or any similar substance, since they would all be solidified at this temperature. I have, therefore, made use of nitrogen which only solidifies at — 211 deg., and which can, moreover, be added to the hydrogen, before its expansion, without causing any complication, at least in cases when we are aiming at the synthesis of ammonia. A current of compressed and dried nitrogen is cooled down to about its condensation point in the heat-exchanger E by means of the tube system X Y; it is then added to the hydrogen at Z, before the hydrogen enters the expander. In this way, then, we secure suitable conditions for the lubrication. As a first consequence the temperature of the escaping gas is easily lowered down to — 208 deg. and — 210 deg. C., as soon as we lubricate by means of nitrogen. As a second consequence, this addition of nitrogen to the gases leaving the tubular system increases to any extent that we desire the calorific mass of the expanded gas. The latter gas may therefore equal or surpass in mass that of the gas ascending in the tubes F, including the carbon monoxide which has been condensed in this part of the tubes. As a result the temperature of expansion is considerably improved and is, moreover, much better utilised. We can, indeed, easily, eliminate by these means the carbon monoxide within one per cent., and the hydrogen finally isolated can without any difficulty be used in my hyper-compression process for the synthesis of ammonia.

This process has been developed and put into practice in the works of La Grande Paroisse, near Montereau, where an apparatus for the production of 500 m³ of hydrogen per hour is in operation, feeding a unit for 5 tons of ammonia per day. The carbon monoxide containing all the nitrogen of the water gas, it should be noted, is discharged at a percentage which may easily be raised to 85. The hydrogen efficiency is therefore excellent. The carbon monoxide may be utilised, either for the manufacture of various chemical products, or for driving the internal-combustion motors of the installation.

The process which I have outlined requires the compression of the gases to degrees, varying with the size of the apparatus from 15 to 30 atmospheres. The first figure applies to apparatus of a capacity of 2,000 m³ of hydrogen per hour. This process necessitates the use of relatively high motive power, and attention might be drawn to the advantages offered by processes based upon the catalysis of CO into CO_2, such as are, for instance, employed in the Haber process. I have hence only studied and tried this process with a view to its ulterior application to a particularly interesting case, that of the coke oven furnaces, in which the presence of a considerable portion of methane renders catalytic processes inoperative. The complexity of the gas mixtures we have to deal with in this case, and the diversity of the freezing points of the constituents might lead us to expect that we should meet serious difficulties in the working of this process. As a matter of fact, however, an apparatus has already been constructed for this purpose, and has after very short trials, been put successfully to service in the Béthune mines. The essential cause of the success is the very high reciprocal solubility of the diverse condensable constituents. This first apparatus has a productive capacity of 350 m³ of hydrogen per hour, and it is operating with

* Paper read before the Faraday Society, Monday, October 16, 1922.

a compression of about 25 atmospheres. An installation for the utilisation of the hydrogen produced by means of this apparatus in the manufacture of ammonia by the application of hyper-compression has already been erected and is actually being put into working order. I hope that this installation will be the point of departure for a much more important installation in which I intend to make use of apparatus for the production of 2,000 m^3 of hydrogen per hour.

One of the essential reasons that make me count upon a development of this process in the coke-oven industry lies in the multiple indirect advantages which the process promises.

On the one hand, since the gases to be treated must already be compressed for the extraction of the hydrogen, we are naturally led to effect the stripping of the gas of its benzol, likewise under compression. All the benzol, which at present escapes, when the process is carried out at atmospheric pressures, will then easily be retained; that will constitute a gain which in certain cases may amount to 1 kg. of benzol per ton of coke. This improved recovery will moreover be attained by means of a greatly reduced amount of solvent and of heat energy, and with much diminished losses of solvent. The recovery will be effected in absorption and distillation apparatus of comparatively very small dimensions. On the other hand, the ethylene, this precious gas the percentage of which in furnace gases is too low for its successful extraction at atmospheric pressure, may easily be collected to a large extent in the course of the operations. For it will alone be condensed almost in the preliminary cold-exchanger of the apparatus, and it can be extracted as a 40 per cent. or 50 per cent. mixture which will very readily be utilisable, either for the manufacture of alcohol or for use in autogeneous welding or similar apparatus. To give an idea of the possible importance of this by-product I may state that, supposing the furnace gas treated to contain 1·5 per cent. of ethylene and that it can all be extracted, that would correspond to our obtaining 200 litres of alcohol per ton of ammonia, in addition to other products.

Finally, I should remark that, from the calorific standpoint, hydrogen must be regarded as the very worst of all combustible gases. One cubic metre of hydrogen represents only about 2,600 calories (lower calorific power) against the 3,000 calories of carbon monoxide and the 10,000 of methane. When therefore we extract the hydrogen from coke oven gases we, in fact, enrich the gases in a true sense, and it is a considerable enrichment which they undergo, since they become fit for uses, for which they would otherwise be unsuitable. When the gas is to be distributed, it will be absolutely free of every trace of the condensable impurities that cause so much mischief in our present gas distribution systems; when it is to be utilised as industrial gas, it will enable us to obtain extremely high temperatures and to combine under specially interesting conditions, the production of nitric oxide by the Häusser process with the synthesis of ammonia.

These are the principal advantages of the process which I have the honour to describe to you. I should like to emphasise that one of the characteristic essential features of the process is the extremely small size of the necessary apparatus. An apparatus for 1,000 m^3 of hydrogen per hour requires a group of liquefaction tubes, 40 cm. in diameter and 3 m. in height.

MINERALS IN THE MALAY PENINSULA.—Some months ago, it was reported that a deposit of hematite ore was being exploited by a Japanese company on Bukit Menia, near the Batu Pahat River in Johore. It is now reported officially that a deposit of ilmenite (titanic iron ore) has been discovered in Ulu Sedili in Johore, and that iron ore of one kind or another exists over an extensive area in that State. A Japanese company holding a prospecting licence for coal near Kluang has reported its failure to locate any coal; but inquiries have been received by the Johore Government regarding a deposit of unusually pure sand at Batu Pahat, which it is thought may be suitable for glass-making. With reference to the location of a large hematite deposit at the north end of Gunong Panjang, close to the high road from Ipoh to Tambun, in the State of Perak, Straits newspapers state that *personnel* and transport are at present unavailable for the immediate working of the ore. This deposit is said to contain upwards of 5,000,000 tons or 6,000,000 tons within 100 ft. of the surface. A Singapore foundry has agreed to buy any quantity.

BRAZILIAN RAILWAY ELECTRIFICATION.—Under this title a recent issue of *Modern Transport* states that the much-desired contract for the electrification of the Central Railway of Brazil, valued at 2,000,000*l.*, should have gone at length to an American corporation—the General Electric Company—is largely explicable upon the ground that, whereas British tenders would doubtless have been accepted had they been of a more definite nature, the condition of trade in this country and the uncertainty of labour rendered it practically impossible for bidding firms to quote an all-in price. Another difficulty encountered—and this was experienced by both British and American contractors—has been the lack of technical knowledge possessed by the responsible advisers to the Brazilian Government. Unsettled opinions of specialists have proved serious in connection with the Central Railway electrification scheme. Other difficulties which have confronted British contractors have not been met with in the United States; in the latter country, notwithstanding the unrest in labour circles, the successful contracting firm has such abundant resources by reason of its immense and varied ramifications, that it has not considered it in any way imprudent to take the risk of quoting the Brazilian Government an inclusive price, leaving only certain details of minor importance for future settlement.

CATALOGUES.

Wire Testing Machines.—A power-driven machine for testing wire in torsion is described in a catalogue received from Messrs. Bruntons, Musselburgh. The machine is suitable for wires up to ¼ in. in diameter.

Pipes.—The usual monthly catalogue of cast-iron pipes in stock and an enlarged list of users of their reinforced concrete pipes have been received from the Stanton Ironworks Company, Limited, near Nottingham.

Gas Valve.—A valve for gas fires which may be adjusted to prevent a given temperature from being exceeded is described in circulars received from Mr. George Wilkinson, Beech-mount, Otley-road, Harrogate.

Hydraulic Presses.—New catalogues giv ng prices and particulars of tyre and scrap presses, have been issued by Messrs. Hollings and Guest, Limited, Thimble Mill-lane, Birmingham.

Files.—Round and half-round files cut with a chaser and made in 12-in. to 18-in. lengths, with the three usual cutting grades, are the subject of a special catalogue issued by the makers, Messrs. John Bedford and Sons, Limited, Sheffield.

Cable Spans.—A paper by Mr. E. Parry dealing with the design of cable spans for power transmission lines has been reprinted and issued by the English Electric Company, Limited, Queen's House, Kingsway, London, W.C. 1.

Electric Lighting Sets.—Particulars of their small oil-engine driven generators, including prices and all export data, are to hand from the Alden Engine Company, Limited, Oxford. The capacities of the standard sizes, in kilowatts, are ¾, 1½, 2, 2½.

Small Tools.—A very wide range of spanners, pliers, pipe wrenches, vices, screwing tackle and other workshop accessories, is shown in a priced catalogue received from Messrs. T. C. Jones and Co., Limited, 93, Wood-lane, Shepherd's Bush, London, W.

Piston Ring Tester.—A description and working directions for testing the pressure required to compress piston rings have been issued by the Adolphe Saurer Company, Arbon, Switzerland. The instrument was described in our issue of February 24 last, on page 239.

Scaling Tool.—An electrically driven tool for the scaling of boilers and boiler tubes, and also useful for brushing and painting is described in a catalogue issued by Mr. O. N. Beck, 11, Queen Victoria-street, London, E.C. 4.

Cranes.—A special catalogue of hand-operated overhead cranes with traverse in one or two directions, and of wall jib cranes with swing and traverse motions, is to hand from Messrs. Herbert Morris, Limited, Loughborough. Prices are stated.

Electric Lanterns.—Particulars of an anti-vibration suspension device, lanterns for ¼-watt lamps and ship and shipyard lantern fittings are given in leaf catalogues received from the Engineering and Lighting Equipment Company, Limited, St. Albans.

Electric Lifting Blocks.—Electric blocks with lifting capacities ranging from 10 cwt. to 3 tons, are described in a special catalogue which has reached us from the makers, Messrs. Joseph Adamson and Co., Hyde, Cheshire.

Hand Tools.—A number of light and powerful tools for shearing rods, flat and corrugated sheets, punching and similar work are illustrated on a wall sheet received from the Tangent Tool Engineering Company, Limited, 40, Great Marlborough-street, London, W. 1.

Firebricks.—A catalogue illustrating the shapes and giving the sizes of standard forms of silica and fireclay bricks comes from the Consett Iron Company, Limited, Durham. All the usual forms of squares, wedges, radius, semi-circular, channel and tongue and groove matching bricks are included.

Cable Joint Box.—A bell cover for joint boxes, designed to allow for contraction of the filling compound during cooling so that the box can be buried immediately after pouring is described in a special catalogue issued by the British Insulated and Helsby Cables, Limited, Prescot, Lancashire.

Fans, &c.—Fans for many special purposes and air heaters, forges, blowpipes, core-drying sets, gas governors, high-pressure gas equipment and other similar products, are illustrated and described in a catalogue received from the Blackman Export Company, Limited, 374, Euston-road, London, N.W. 1.

Transformers.—In the series of transformer pamphlets issued by Messrs. Johnson and Phillips, Limited, Charlton, London, S.E.7, the ninth number deals with current distribution with interconnected star static balances, and the tenth contains a comparison of polyphase transformer connections.

Marine Oil Engines.—The Werkspoor Company, Amsterdam, have sent us a copy of the new edition of their catalogue of marine oil engines—a publication always of considerable technical interest. The work now in hand by the company, when completed, will bring their total production since 1903 up to 100,000 h.p.

Oil Engines.—A list of vertical oil engines ranging from 10 h.p. to 200 h.p. in fixed land type and up to 75 h.p. in marine type, with specification and illustrations, is to hand from Mr. E. W. Dorey, Norwich House, Southampton-street, London, W.C. 1, who is agent for the makers, the Anglo-Belgian Company, Limited, Ghent.

Woven Wire for Screens.—A catalogue of woven steel wire for screens, stating the thickness of wire, area of aperture, meshes per square inch and percentage of discharge area, and giving full particulars of cloths having from 64 to 1,600 meshes per square inch, is to hand from Messrs. Richard Johnson, Clapham and Morris, Limited, Lever-street, Manchester.

Electric Locomotives.—A catalogue from the Westinghouse Electric and Manufacturing Company, East Pittsburg, U.S.A., contains much useful information on electric locomotives of both the trolley and storage battery types, for mining and ordinary industrial use. The illustrations of the conditions under which these locomotives operate are of special interest.

Electric Fuse.—A four-page catalogue describing a fuse for extra high tension currents up to 115,000 volts has come to hand from the Electric Control, Limited, Glasgow, and Hastings House, Norfolk-street, Strand, London, W.C.2. The fuse is intended for protection against short circuits and not for ordinary overload protection.

Sawing Machines.—A catalogue of machines with circular "toothless" saws is to hand from Mr. F. Curt Schmidt, 82, Victoria-street, London, S.W. 1. The saws, which have corrugated edges, range from 20 in. to 50 in. in diameter, and the peripheral speed used is about 350 ft. per second. In saws of this type the cutting is effected by local heating due to friction.

Tool Steel.—High speed steels of several kinds, including the original Mushet self-hardening steel, and reamers, twist drills, milling cutters, and hobs made from these steels are dealt with in a catalogue received from Messrs. Samuel Osborne and Co., Limited, Sheffield. Instruction for forging and heat treatment are given for each steel, and several useful tables are included.

Engines and Boilers.—Messrs. Marshall, Sons and Co., Limited, Gainsborough, have issued new editions of their catalogues of portable steam engines, semi-portable engines with boilers, and Cornish and Lancashire boilers, a leaf catalogue describing a water cart with pump and horse shafts and draw bar, and another illustrating their method of constructing boilers for road engines, have also come to hand.

Insulators.—A material having insulating properties which are claimed to be at least equal to those of porcelain and with the additional advantage of toughness, is described in a catalogue received from Messrs. Callender's Cable and Construction Company, Limited, Hamilton House, Victoria-embankment, London, E.C. 4. A wide range of insulators made of this material, which is known as "Kalanite," is illustrated.

Gas Meter.—A description of the Thomas gas meter, which records in standard cubic feet the quantity of gas or air passed without requiring any corrections for variation of pressure, temperature, &c., is given in a catalogue received from the Cambridge and Paul Instrument Company, Limited, 45, Grosvenor-place, London, S.W. 1, who manufacture and sell these instruments in agreement with the American firm which introduced them.

The Ruston Wood-Refuse Gas Producer.—We have received from Messrs. Ruston and Hornsby, Limited, of Lincoln, a folder giving a statement of the costs of producing 100 h.p. for a year, by means of electric motors, steam, gas and oil engines as compared with the performance of the same duty by an engine driven by a producer plant working with wood refuse. The comparison is shown to be very decidedly in favour of the latter plant.

Electric Driving.—Two catalogues dealing respectively with electric driving in woollen mills and metal rolling mills, are to hand from the English Electric Company, Limited, Queen's House, Kingsway, London, W.C. 2. The first illustrates the electric drive applied to nearly all the machines used in the manufacture of woollen materials, from scouring the wool to finishing the woven cloth. The other catalogue presents, without comment, 20 views of the main types of rolling mills in which the electric drive is used.

Squared Papers.—A book of samples of squared paper has been issued by Messrs. Wightman, Mountain and Andrews, Limited, 31, Victoria-street, London, S.W. 1, who specialise in this material. The inch squares are subdivided into 4, 5, 8, 10, 12, 16, 20 parts, and there are also samples of millimetre, profile, logarithmic and progress-curve papers. A great variety of drawing and tracing papers, tracing cloths and cloth mounted papers is also supplied by the firm in the form of pads and pocket books as well as in standard sheets and rolls.

Rotary Pumps.—A catalogue of rotary pumps made in 14 standard sizes for power drive, and 5 standard sizes for hand drive, with suitable connections for water, oil, tar, molasses, milk and other liquids, is to hand from Messrs. Stothert and Pitt, Limited, Bath. These pumps will work against pressures up to 100 lb. per square inch. in one class and up to 200 lb. per square inch in another class, and special designs are available for pressures up to 750 lb. per square inch. The catalogue contains much relevant technical data and numerous graphs showing working capacities under various conditions.

Petrol and Oil Engines.—Messrs. R. A. Lister and Co., Limited, Dursley, Gloucester, send us a number of catalogues of their small petrol and oil engines developing from 1½ h.p. to over 30 h.p., and of the lighting, pumping and other machines to which the engines are coupled. Included among them is an automatic electric light plant, in which the engine is started by switching on the light; a similar set started by hand; pumping sets of several capacities with ram or rotary pumps; and portable engines for agricultural, building and similar work. An excellent booklet, also issued, containing a description of the engine with instructions for operating and cleaning it should prove of service to users.

THERMOMETER LAG IN COLD STORAGE PRACTICE.*

By Ezer Griffiths, D.Sc., and J. H. Awbery, B.A., B.Sc., National Physical Laboratory.

Temperature control is a factor of vital importance to the successful operation of a cold store. Simple mercury-in-glass or spirit thermometers are almost universally used for such purposes; for distant reading work the resistance thermometer and mercury-in-steel thermometers offer advantages. When in measuring the temperature of the atmosphere in a ship's hold the thermometer has to be withdrawn from the hold to the deck, errors may arise; these and the time-lags, likely to arise with rapidly changing temperatures, have been investigated.

Description of Thermometers—Mercury-in-Glass and Spirit Thermometers.—The thermometer illustrated in Fig. 1 was designed by Mr. A. R. T. Woods, managing director of the Nelson Line, to eliminate the error arising when a bare thermometer is taken up to the deck for reading. The stem and bulb are protected by a wooden sheath, and the bulb is lagged with cotton waste; the device has proved efficient. The mercury thermometers tested have bulbs 1 in. long, ¼ in. in diameter; the spirit-thermometer bulbs are 1¼ in. long, ⅜ in. diameter.

Distant-Reading Mercury-in-Steel Thermometers.—The steel bulb, 8 in. long, ¼ in. diameter, is connected by a fine capillary to a Bourdon tube, and the temperature is read off on a dial.

Resistance Thermometer (Fig. 2).—The bulb consists of a spool of porcelain, $2\frac{3}{16}$ in. long, $\frac{7}{16}$ in. in diameter, wound with platinum wire as shown; after winding, the spool is dipped in a glaze to protect the platinum. The whole is enclosed in a copper tube, mica being interposed between the spool and the copper. In the research a number of these thermometers were connected to one indicator and plugged in as desired.

Calibration at Low Temperatures.—Calibration at temperatures below freezing-point was effected with the aid of the apparatus, illustrated in the diagrams, Figs. 3 and 4. For plain thermometers the Dewar vacuum vessel (not silvered) fitted with a drawing-off pipe (Fig. 3) is used. A tube projects into the vessel containing a shaft with propeller blades. When the motor is in action, the liquid is sucked up the central tube and is discharged out through orifices, a thorough stirring being thus secured. The thermometers are carried on clips attached to the tube and are totally immersed; the readings are taken through the transparent walls of the vessel. The liquid employed is clean, anhydrous ether to which carbon dioxide snow (prepared by allowing the liquid carbon dioxide of a cylinder to expand into a perforated container) is added; temperatures down to − 60 deg. C. (− 76 deg. F.) can be obtained.

Larger instruments are calibrated in the apparatus Fig. 4, which also serves for time-lag determinations. Within a box, 2 ft. by 2 ft. by 2 ft. internal dimensions, is a spiral of iron piping connected to the refrigerating plant; by circulating the expanded ammonia in this spiral the temperature can quickly be lowered to − 35 deg. C. (− 31 deg. F.). The bulb of the instrument under test projects into the box; a number of thermo-junctions of copper-constantan are attached to the bulb, and a freely-suspended junction gives the enclosure temperature. The method is not applicable to thermometers inserted in pipe lines which usually have an emerging column; such instruments should be tested under service conditions, *e.g.*, in a cast-iron box inserted in a pipe line connected through a pump to the cold brine reservoir; the thermometers are screwed into sockets in the top of the tank.

Time-Lag Determinations.—The temperature of the enclosure of Fig. 4 is lowered down to a point corresponding with the lowest scale reading of the thermometer under test. The thermometer, initially at room temperature, is rapidly inserted into the enclosure, and readings of apparent temperatures are taken at intervals. The curves obtained (Fig. 5) are exponential, and the observations can hence be shown graphically on a series of straight lines, by plotting the logarithm of the temperature excess against the time (Fig. 6); the slope of any of these lines determines the relative time-lag, that is to say, the smaller the slope, the greater the time taken to settle to a state of equilibrium. The formula deduced in the paper, indicate, for instance, the way in which a thermometer taken from one room into another colder by T deg. would acquire that new temperature.

Results and Applications.—A constant found to be convenient for time-lag calculations, had the following values, in minutes, for the different thermometers: Plain mercury 3·38, spirit 6·11, wood-encased mercury 14·57, direct reading platinum 17·29, mercury-in-steel, distant-reading, 18·28 minutes. With the aid of these constants a table has been prepared showing the error introduced in temperature determination by first holding the instrument for t seconds at a temperature by N deg. lower or higher than the actual temperature. Examples of the use of this table were given.

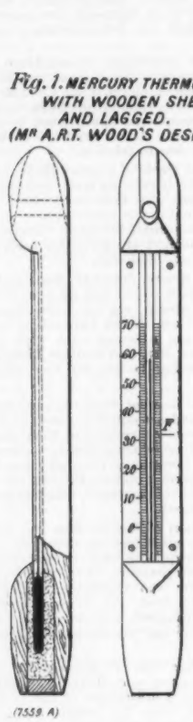


Fig. 1. MERCURY THERMOMETER WITH WOODEN SHEATH AND LAGGED. (Mr A.R.T. WOOD'S DESIGN.)

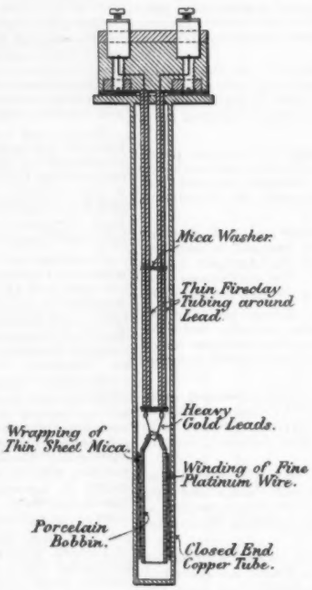


Fig. 2. INDUSTRIAL FORM OF RESISTANCE THERMOMETER.

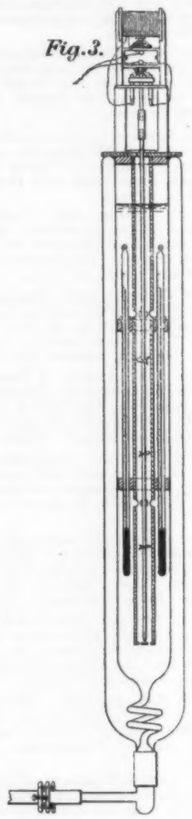


Fig. 3.

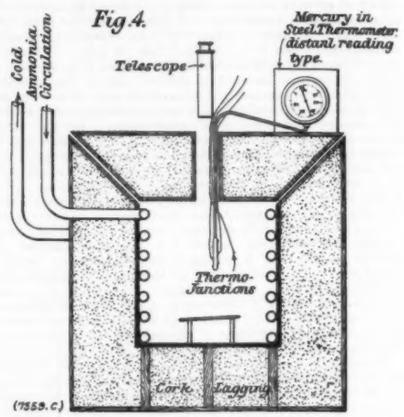


Fig. 4.

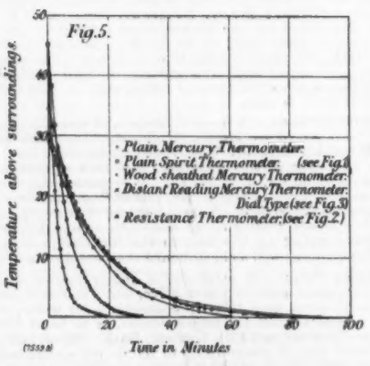

Temperature above surroundings.
Plain Mercury Thermometer.
Plain Spirit Thermometer. (see Fig. 1.)
Wood sheathed Mercury Thermometer.
Distant Reading Mercury Thermometer. Dial Type (see Fig. 3)
Resistance Thermometer (see Fig. 2)
Time in Minutes.
(7559 B)

Fig. 5.

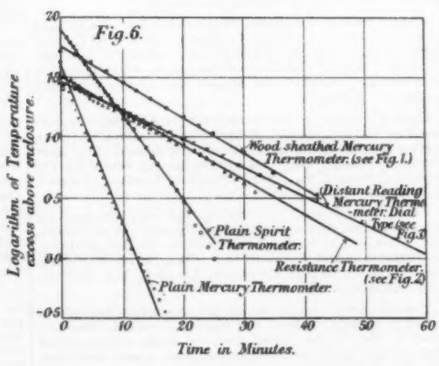

Logarithm of Temperature excess above enclosure.
Wood sheathed Mercury Thermometer. (see Fig. 1.)
(Distant Reading Mercury Thermometer. Dial Type (see Fig. 3.)
Plain Spirit Thermometer.
Resistance Thermometer. (see Fig. 2)
Plain Mercury Thermometer.
Time in Minutes.

Fig. 6.

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* Abstract of a paper read before the Faraday Society, October 16, 1922.

The Port of Aden.—The report for the year ending March 31, 1922, for the port of Aden shows the total tonnage making use of the port in the year to have amounted to 3,388,304. The tonnage of merchant vessels calling was about 1,000,000 less than in 1913–14, but the Government vessels represented twice the amount registered in that year. In the year 1918–19, more than two-thirds of the total, represented Government tonnage, but last year it had fallen to less than one-eighth. The receipts for the year totalled Rs. 10,23,225, and the expenditure being Rs. 9,07,009, a total balance in hand remained at the end of the year of Rs. 11,60,235. During the year the sum of Rs. 1,61,372 were spent in improvements. Of this Rs. 94,267 were from revenue and Rs. 67,104 from the depreciation and replacement fund. The latter closed the year with a balance of Rs. 72,143 in hand.

German Industry.—The *Verein Deutscher Ingenieure*, Berlin, has published in the English language a special issue dealing with air, refrigeration and gas. It contains, besides a large number of advertisements, in which the references are given in English, French and Spanish, a series of illustrated articles describing air compressors, blowers, fans, compressed air locomotives, drills and hammers, with articles on refrigeration, on liquefaction and separation of air, &c. The issue is admirably got up. The *Verein* announces that a similar issue has been published in French and in Spanish. We have received at the same time a pamphlet in German, issued by the Heimkultur-Pressedienst, Wiesbaden, on the Krupp buildings and garden cities. This concern, the Heimkultur, "has introduced a method of constructing buildings which is of international importance, making use of waste materials, thus enabling it to build cheap houses . . . Unfortunately Germany has to suffer severely on account of reparations and sanctions, so that owing to heavy costs it is almost impossible to edit books and journals; Germany, must therefore, look to selling abroad." Heimkultur asks us to mention this fact in our columns. We do so, and advise it to get into touch with the *Verein Deutscher Ingenieurs* with reference to its publications.

INDUSTRIAL METHODS OF LIQUEFACTION AND PRACTICAL APPLICATION OF LOW TEMPERATURES.*

By K. S. MURRAY.

IN introducing his paper, Mr. Murray mentioned that the title had not been selected by himself. He would have time only to deal with the separation of the constituents of air. By that people generally meant the extraction of oxygen from the atmosphere. "I have been engaged in extracting vastly more than my fair share for the last thirty-five years. The history of the British Oxygen Company with which I have been associated for the whole of that period, is so intimately bound up with the industrial development of oxygen that it is impossible, at any rate for me, to consider these subjects apart."

Mr. Murray then outlined the Brin process of the British Oxygen Company, established in 1886 as Brin's Oxygen Company, as described by him before the Institution of Mechanical Engineers in 1890 (see ENGINEERING, vol. xlix, page 149). In their modified process the barium monoxide was not first heated to 540 deg. C. to absorb more oxygen and to form dioxide, and then further heated to 870 deg. C., to give off the oxygen absorbed, but the furnace was kept at 650 deg. C., change of pressure being relied upon for determining the oxidation and deoxidation phases. This process of the British Oxygen Company was exclusively used for nearly twenty years in their factories at London, Birmingham, Manchester and Glasgow, and plants for daily capacities of from 5,000 cub. ft. to 30,000 cub. ft. of oxygen were also erected by them, both in this country and in Paris, Berlin and New York, as the first commercial plants for the production of oxygen. The following is an abstract of Mr. Murray's contribution to the discussion.

Not one of these barium oxide plants remains in operation to-day, although in point of economy the process does not compare unfavourably with liquid oxygen plants of the smaller type; the process was abandoned mainly because it was incapable of producing oxygen of equal purity. As early as 1896 the British Oxygen Company, as makers of the Hampson apparatus for the liquefaction of air, became connected with low temperature research. When expanding 700 cub. ft. of air from 150 atmospheres down to atmospheric pressure, the Hampson apparatus begins to produce liquid in about 6 minutes with a yield of 1 litre (0·22 gallon) of liquid per hour. For commercial production this apparatus was too small. But its success and the still more important work of Carl von Linde induced the company to experiment. It must, however, be admitted that the problem remained entirely unsolved until the process of rectification was disclosed by Linde in 1903; from that date onward rectification has been the fundamental principle underlying every patented method for separating the constituents of liquefied air. The company acquired the British and British Colonial rights of Linde and erected in 1906 the Westminster plant for 500 cub. ft. of oxygen per hour. The photograph of these works exhibited showed that the Linde process and the modified Brin process were for many months worked in the same building side by side, largely on the recommendation of Professor Linde, who was struck with the simplicity and efficiency of the barium oxide process. After prolonged litigation, in 1908, the company further acquired the Claude rights (British and Colonial, except Canada) for the separation of oxygen and nitrogen from air, by arrangement with the Société l'Air Liquide. In many of our factories we have to-day Linde and Claude plants working side by side.

The earliest type of Linde plant for the separation of oxygen from liquid air consists essentially of an air compressor; a purifier for eliminating carbon dioxide; a drier for removing moisture; a pre-cooler, kept cold by an ammonia or a CO_2 machine; the separator containing the counter-current heat interchanger and the rectification column. Air is drawn by the compressor through a purifier (lime or caustic soda) and isothermally (so far as possible) compressed to 135 atmospheres and sent through a drier containing calcium chloride. In the pre-cooler it is cooled down to − 30 deg. C., remaining traces of moisture being deposited there as ice, finally to pass into the separator shown in sectional elevation in Fig. 1. The main pipe D conveying the compressed air is split into three small pipes d when it enters the interchanger coil C. The air passes down those pipes which are reunited into a single pipe d_1 when they leave the interchanger; d_1 is cooled in the vaporiser B and attached to the inlet of the valve G. By adjustment of the regulating valve spindle H the air is caused to expand and is discharged at low pressure through the rose-ended pipe d_2 into the top of the rectification column A. The expanded air fills the column A and flows through the only two possible outlets pipes c and e, which surround the small pipes d, thus forming the counter-current heat interchanger, the expanded air ascending. The expanded cold gases, having extracted heat from the incoming compressed air, leave the separator at C and E.

Linde obtains the Joule-Thomson cooling effect in the valve G, and he makes it accumulative by means of the counter-current heat interchanger. After starting the lagged apparatus in its wooden casing with everything at atmospheric pressure, the separator gradually cools until liquid air collects round the coils in the vaporiser B; the quantity of liquid is registered outside by means of an ordinary coloured liquid contained in a glass tube b, which is enclosed in a pressure-equalising circuit. Once this stage is reached the liquid accumulates rapidly in B, and the initial pressure of the compressed air may gradually be reduced by increasing the opening of the valve G. The compressed air transmits some of its latent heat to the liquid, which is therefore evaporated, whilst the compressed air is itself liquified in proportion to the amount of heat thus extracted. The vapour produced flows upward through A, while the liquid formed in the compressed-air pipe coil d_1 ascends through pipe d_2 and is discharged through the rose. The temperature gradient necessary for efficient rectification then rapidly becomes established in the column, and the final stage is reached under which the separation of oxygen is effected. The pipes C and E then begin to fulfil their proper functions, the nitrogen being delivered through C from the top of the column, and the oxygen vapours through E from the top of the vaporiser. The separated gases leave nearly at atmospheric temperature having abstracted heat from the incoming compressed air.

The principle involved in the action of this simplest type of rectification is involved in all the others. For his temperature gradient Linde relies on the difference between the boiling points of nitrogen, − 196 deg. C. and oxygen − 183 deg. C. Liquid air is discharged into the top of the column at an intermediate temperature of about − 194 deg. C. As the air passes down, the more volatile nitrogen evaporates off, the liquid becoming richer in oxygen and also warmer. As this rich oxygen liquid accumulates it is itself evaporated by the heat of the compressed gas circulating through the coil, until it is practically pure oxygen, very nearly at − 183 deg. There is thus a temperature gradient of about 11 deg. C. established between the top and the bottom of the column. Liquid air passing down the column is brought into contact with the rising vapours of oxygen, and an exchange of material takes place. At each stage some of the rising oxygen is condensed, and some of the nitrogen in the descending liquid is evaporated, while the liquid gradually gains in temperature until, by the time it reaches the vaporiser, its composition is that of practically pure oxygen. The gas escaping through C is mainly nitrogen at a temperature 11 deg. lower than that of the oxygen at the bottom of A. The oxygen rising in A to effect the material exchange is carried back to the vaporiser together with most of the oxygen in the original liquid; thus there is a constant accumulation of oxygen which passes off through E.

When normal oxygen-producing conditions are established, the air supply from the condenser becomes reduced from 135 to 55 atmospheres, the latter pressure being sufficient to make good all heat losses. This type of separator is easy to operate and economically satisfactory for use in relatively small oxygen plants. The defect is that, though an oxygen of high purity can be produced, the waste nitrogen carries at least 7 per cent. of the oxygen away with it, and this loss is inevitable because Baily demonstrated in 1900 that the vapour in equilibrium with a liquid mixture of oxygen and nitrogen always contains more nitrogen than the liquid, and that the proportion of oxygen in the vapour is 7 per cent. when the evaporating liquid is air, and the liquid air enters at the top. This loss of one-third of the oxygen becomes a serious matter in large plants, and Claude, I believe, was the first to design a separator obviating this loss. To maintain chronological order I will therefore describe the type of a Claude plant capable of producing 4,000 cub. ft. of oxygen per hour, as largely employed by the British Oxygen Company at present in nearly all their factories. The outstanding features of the plant are: Cooling by means of an expansion engine; a selective system of rectification rendered possible by preliminary partial separation of N and O; a combined system of heat interchange and drying rendering chemical absorption of the moisture unnecessary.

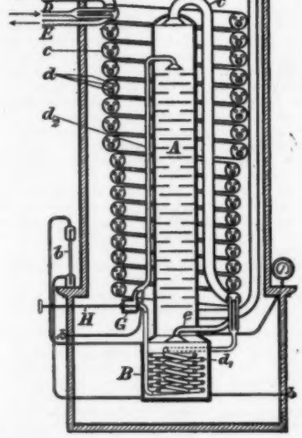

Fig. 1.

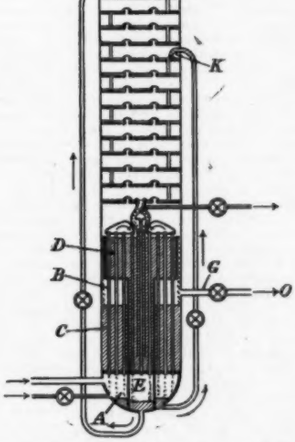

Fig. 2.

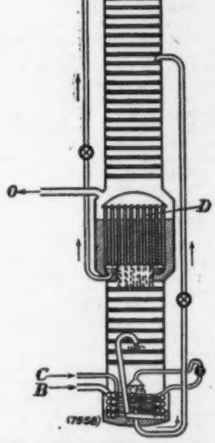

Fig. 3.

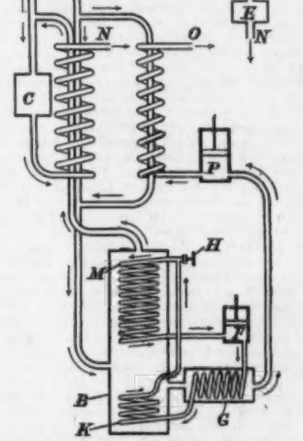

Fig. 4.

Air is drawn by a compressor through purifiers to remove the CO_2; it is then compressed to 33 atmospheres max. and passed through two vertical tubular heat interchangers in series; in the second of these it meets in counter-current the cold-separated O and N passing outward. A very complete heat interchange takes place; most of the moisture is thrown down, the rest forms an ice coating round the tubes at the top of the interchanger Meanwhile the first interchanger is being thawed by the air passing through it; the two interchangers are operated alternately, being changed over at intervals of 8 hours. The compressed air leaves the second interchanger at about − 100 deg. C. Sixty per cent. or 70 per cent. of the cooled air goes direct to the expansion engine where it performs work in expanding to 4 atmospheres against a dynamo brake, and issues from the engine nearly at liquefaction temperature. The rest of the air passes under full pressure into an interchanger, the liquefier, where it is liquefied by meeting in counter-current all the O and N passing from the second, operating, interchanger, the cold vapour from the expansion engine and the liquid from the liquefier both enter the outer compartment A of the liquid-collecting vessel (Fig. 2) at the bottom of the vaporiser, the valve shown controlling the liquid like the Linde valve G. By this skilful combination of internal and external expansion Claude is able to obtain a high efficiency from his expansion engine. For this latter purpose the compressed air should be as warm as possible. By passing the cold gases through a liquefier a twofold purpose is served. First a moderate supply of liquid for making good cold losses is assured, by an effective heat interchange coupled with the Linde internal expansion. Second, the heat usefully abstracted by the gases from the compressed air, passing in counter-current through the liquefier, raises their temperature to a point which prevents their abstracting, at a later stage, too much heat from the compressed air passing through the main interchanger into the engine.

Thus an adjustable supply of liquid air and cold vapour is fed into the outer compartment A below the vaporiser. This vapour ascends in the vertical tubes B which are immersed in baths of liquid oxygen C and D, in which the vapour undergoes progressive liquefaction, the less volatile and more condensable oxygen flowing back into the compartment; there is also scrubbing so that the gas leaving the tubes at the top is very rich in N. This N travels down a similar nest of tubes leading to the inner compartment E,

* Contribution to the discussion on "The Generation and Utilisation of Cold," held by the Faraday Society and the British Cold Storage and Ice Association, October 16, 1922. Abridged.

which it reaches partly as liquid. In practice the liquid obtained in the outer compartment contains 40 per cent. of O, that in the inner 4 per cent. of O. A pressure of 4 atmospheres is necessary in these compartments in order to raise the liquefying point of the O – N mixture above – 183 deg., the temperature of the liquid O bath, so that liquefaction may take place and that latent heat may pass to the liquid oxygen and evaporate it to a corresponding extent. Above the vaporiser, as in the Linde apparatus, is the rectifying column H, to the top of which the liquid, rich in N, is conveyed from the inner compartment E; while the liquid with 40 per cent. O is conveyed from the outer compartment A to the column at K, where the composition of the ascending gases should correspond to that of a gas mixture in equilibrium with a 40 per cent. O mixture. Rectification with the proper temperature gradient then proceeds as in the Linde case, Fig. 1, with the important difference, however, that as liquid rich in N replaces liquid air at the top of the column, a correspondingly lower temperature is maintained there, and nearly all the oxygen is abstracted from the air. The waste N passes down the liquefier interchanger, and the oxygen is taken away through pipe G. Through the small additional nest of tubes in the centre of the vaporiser a quantity of rich N can be withdrawn from E as indicated; after this additional scrubbing a small, but useful, amount of N of 99·5 per cent. to 100 per cent. purity, can be obtained as a by-product.

All parts of the apparatus at temperatures below atmospheric are efficiently insulated. When working conditions are established the compressor delivers air at 26 atmospheres, the initial 33 atmospheres being the maximum used to hasten cooling down. This is less than a quarter of the initial pressures of Linde and others and, besides being a fine tribute to the efficiency of the Claude expansion, admits of employing lighter materials and a more efficient design for the interchangers and elsewhere. A striking feature of the engine is that it works without any cylinder lubrication; specially-prepared leather, from which water and fatty matter have been removed, serves as piston packing and remains pliable at low temperatures.

These plants, under daily working conditions, produce a 98·5 per cent. oxygen at 185 b.h.p. per hour, or 46 b.h.p. per 1,000 cub. ft. of oxygen, the labour required for working the plant being no more than is required for a plant one-tenth the size. We do not employ larger plants. We do not employ Linde plants of more than 2,000 cub. ft. of O per hour; so far as the separator is concerned, these and all larger Linde plants are similar in most respects to the Claude design.

In producing cold with these larger plants, Linde does not use an expansion engine, but he still relies on the Joule-Thomson effect of internal expansion. On the other hand, he economises power by compressing only one-third of the air to a constant pressure of 135 atmospheres, compressing the other two-thirds to 4 atmospheres. Like Claude he thus admits both liquid and gaseous air to his separator to obtain similar results with very little more expenditure of power. The double-column separator of Linde (Fig. 3) consists of two rectification columns, the lower one working under 4 atmospheres, like the condenser tubes of Claude, the upper under atmospheric pressure. The air at 135 atmospheres enters the bottom vaporiser at C and is liquefied as in the single-column apparatus, Fig. 1; this supply of liquid air makes good all cold losses. The low-pressure gaseous air enters the bottom vaporiser at B; passing through a separate coil it is discharged into the lower coil about the centre as shown, from which point it rises to a nest of tubes D surrounded by a bath of liquid oxygen as in the Claude system. Here partial liquefaction occurs, the liquid falling back over the plates with a scrubbing effect on the rising vapour; most of the O is thus removed to collect as liquid in the lower vaporiser. The remaining gas, practically pure N, passes over to be condensed in the external tubes. Thus liquids, rich in N and O respectively, are supplied to the upper column for final rectification. Both N and O are drawn off as indicated through a counter-current interchanger similar to that of Fig. 1, in order to abstract heat from the incoming air of the high and low-pressure supplies, the whole being similarly insulated. As in the smaller plants Linde employs an auxiliary pre-cooler (ammonia or CO_2 machine), also for separating out the moisture.

I am not able to speak from personal experience of a Linde plant of a capacity of more than 2,000 cub. ft. of O per hour. This latter plant, however, absorbs 106 b.h.p. per hour, or 53 b.h.p. per 1,000 cub. ft. of O produced. Both Linde and Claude oxygen separators have been made up to a capacity of 9,000 cub. ft. of O per hour, the power consumed per 1,000 cub. ft. of O produced being 33 b.h.p. I believe the Linde Company have also manufactured larger units for which they claim still lower power consumption. But the construction of efficient heat interchangers for large oxygen plants is likely to put a limit to their size, and I venture to doubt whether a plant with much lower consumption than 30 b.h.p. per 1,000 cub ft. of O is possible with due regard to economy in other directions.

While on the subject of large plant units reference may be made to the well-advertised Jefferies-Norton process which, we have repeatedly been assured, would produce oxygen at 6*d.* per 1,000 cub. ft. The process appears to be based on the fact that heat interchange should take place between high-pressure gases in order to recover power more effectively than in existing systems, where heat is transmitted from a high to a low-pressure gas. Fig. 4 is a very free diagrammatic illustration of the process as I understand it. Air at, say, 20 atmospheres enters at A, and it is, on its way to the rectification column B (operated at slightly lower pressure), made to pass through two heat interchangers in order to heat up outgoing N and O. The N first passes through its interchanger at full pressure; it is then split up as shown, about 60 per cent. of it being externally heated at D to about 550 deg. C.; this hot, fully compressed gas then enters the motor E, which it drives, giving sufficient power, it is claimed, to work the whole system. The remaining 40 per cent. of N, in order to help in counteracting heat influx, is expanded in the engine C, the expanded gas being employed again to abstract heat from the incoming compressed air. The expanded O leaving the rectification column under pressure passes to the expansion engine P, the expanded O on its way out of the system again cooling the incoming air.

I have already shown that, to maintain the correct temperature gradient in the rectification columns, there should be O vapours at the bottom and N vapours at the top; but when the pressure in the column is nearly the same as that of the compressed air entering it, then the condensation of the latter in liquid oxygen cannot be effected and normal rectification cannot be set up. To get over this difficulty and to transfer heat from the top to the bottom of his column, Norton places a coil K in the liquid O bath at the bottom of the column, through which an independent supply of O, raised by the compressor F to a pressure above that in the column, is caused to flow after having been cooled by the outgoing vapour in G. The circulating O is then condensed in the O bath and afterwards expanded through the valve H to a temperature low enough to condense the N; it is then drawn through the coil M to be recompressed by the compressor F in the enclosed circuit. The Norton process has had the advantage of the support of the U.S.A. Government. A large plant for the extraction of helium from natural gas was erected in Petrolia, Texas; the plant was never successful and has been abandoned, I understand, a plant erected by the Linde Air Products Company of the U.S.A. during the war at Fort Worth, Texas, being employed instead. I have not heard of any Norton plant being successfully employed for oxygen production, and although the process has clever features and is refreshingly original, I am afraid most engineers of experience with very low temperatures will regard it as somewhat impracticable.

There are many makers of oxygen plants to-day, mostly of small size, nearly all based on the original Linde apparatus (Fig. 1) and I am not aware of any possessing novelty on design. Only one maker I know of employs the Claude expansion engine. In that case some of the air from the main compressor, at very high pressure and without previous cooling, is sent through the expander and then through a heat exchanger to the centre of the column. This has certain advantages for the production of liquid air, but cannot economically be adapted, I think, to the production of oxygen. It is apparently claimed as an advantage that ordinary oil can be used for lubricating the expansion engine; but it is a greater advantage of the Claude system that oil need not be used at all.

Cylinder lubricating oil is a source of trouble in liquid oxygen plants in two respects: (1) Traces of oil are liable to be carried forward and to foul the interchanger pipes and the column. (2) The other more serious trouble concerns the air compressor cylinders. In spite of cooling, the heat generated necessitates the use of very high flash-point oils, and precautions not to exceed that flash-point temperature; any lubricating oil heated in the presence of compressed air beyond its flash-point breaks down into simpler substances, including free carbon and acetylene. These substances, especially the acetylene, are carried forward in the air and accumulate as solid particles in liquid oxygen baths; hence numerous explosions, almost all traceable to acetylene. Until the cause became obvious, these incidents were the most disquieting of our experience, but since we have got to the root of the trouble we have greatly reduced the risk by introducing simple safeguards on our compressors.

Hitherto I have only dealt with plants producing gaseous oxygen. Liquid oxygen can be drawn from such plants; but they are not the most convenient construction for the purpose. When the oxygen is withdrawn as liquid, its value as heat abstractor from the incoming air is lost, and this has to be compensated for by increased pressure. So far the application of liquid oxygen has practically been restricted to rescue work and aircraft uses; but its employment as an explosive, developed by the Germans during the war, is likely to extend. The Société l'Air Liquide has recently supplied a liquid oxygen plant for some mines in Lorraine, where German plants had been used; this plant works at 60 atmospheres and produces 75 litres (17 gallons) of liquid oxygen per hour at a power expenditure of 140 b.h.p., less than 2 b.h.p. per litre. We are supplying to South Africa a much smaller plant for higher pressure, which will produce liquid oxygen at 2·5 b.h.p. per litre and will produce gaseous oxygen alternatively. The price of liquid oxygen will always be higher than that of the gas; we sell it at infrequent intervals in small quantities, as drawn from our factories, at prices down to 1*s.* 4*d.* per pound, in small Dewar vessels; but to a regular large customer much better terms could now be offered. In Lorraine where I have seen liquid oxygen extensively used in the iron mines for blasting, it cost 1·50 francs per litre, then equivalent to 7*d.* per litre; the plants I mentioned could easily supply the liquid at this figure. In the improved metallic Dewar flasks of 25 litres and upwards the loss due to ordinary evaporation should not exceed 5 per cent. in 24 hours; in the mines much more is lost during the impregnation of the cartridges.

The cost of gaseous oxygen varies to a larger extent with the size of the plant. Taking a plant for 500 cub. ft. of O per hour as the smallest practicable unit, and a Claude plant for 9,000 cub. ft. per hour, the largest of which I can speak with adequate personal knowledge, as extreme cases, assuming power at 1*d.* per b.h.p. (rather a high figure for the large plant) and the plants to work continuously to full capacity, the total costs, including interest on capital and depreciation, should be 19*s.* and 4*s.* 6*d.* per 1,000 cub. ft. respectively. Working intermittently so that the annual output would be halved, the standing charges would tell in favour of the large plant, and the costs would be 27*s.* and 6*s.* 3*d.* These costs are into the gasholder. With factories supplying the gas in cylinders, supervision, overhead charges, fluctuating demand, &c., would raise the cost in small plants. The factories of the British Oxygen Company in this country are now able to produce 2,000,000 cub. ft. of oxygen per day. Our present sales fluctuate between 4,000,000 cub. ft. and 5,000,000 cub. ft. per week, which is less than half the total capacity. The average price for cylinder oxygen is 38*s.* per 1,000 cub. ft., though substantially lower to many large consumers. That price compares favourably with other countries, I believe, except probably Germany, as to which financial comparison is difficult.

The secret of cheap oxygen is the large liquid-air unit worked to full capacity. By having increased the size of our factories since the war we are able to sell oxygen below our pre-war price. The oxygen business has become a good barometer of trade. The amount of oxygen sold for medical purposes in this country probably does not exceed 1 per cent. of the total output in cylinders. About 3 per cent. is used for lime-light and for experiments; the rest goes to the industries. Metal-cutting represents over 50 per cent. of the industrial demand, and scrap-cutting (destructive work) and constructive work share about equally in this. The latter work is perhaps one of the most promising outlets for oxygen. When the oxygen cutter is used in conjunction with self-feeding profiling machines, it is found to work with the precision of a saw at far greater rapidity. Oxy-acetylene welding claims about 25 per cent. of the gas sold in cylinders, and can easily hold its own in a great variety of work against electric welding and other processes. Most of the remainder of the oxygen is wanted for lead-burning and for obtaining high temperatures in special metallurgical operations. As regards the enrichment of air for blast furnaces and the continuous gasification of fuel, oxygen can hardly yet be produced cheaply enough. In Germany oxygen is used in the manufacture of nitric acid and acetic acid; but so far the use of oxygen in the chemical industry has little been developed. It must be admitted that the industrial development throughout the world is still mainly confined to the cylinder trade. In this country, in spite of the trade depression, the quantity of oxygen distributed in cylinders must, at the present time, approach 300,000,000 cub. ft. per annum, of which the British oxygen Company supplies 225,000,000 cub. ft. The output in France is about the same, but it is stated to be three times as large in the United States and more than twice as much in Germany.

In conclusion, Mr. Murray touched upon the national importance of the oxygen industry.

Mine Ventilation Tests.—The experimental coal mine, operated by the United States Bureau of Mines at Bruceton, Pa., near Pittsburgh, has been put in condition for a study of some fundamental factors that govern the ventilation of mines, by the installation of means for the control of air currents, by the installation of instruments of precision, and by making a long series of calibrations. In one of the rooms of the mine a lead disc, 3 ft. in diameter, has been placed against the coal. Thermocouples have been placed in this disc and also at various depths in the coal and shale roof for the purpose of studying the rate of flow of heat through coal and shale. Such data, when obtained, will be of value in the control of ventilation in deep metal mines.

Switchboards for Melbourne.—His Majesty's Senior Trade Commissioner in Australia reports that the Postmaster-General's Department, Melbourne, is calling for tenders for the supply and delivery of various types of telephone switchboards, namely, common battery cordless type, common battery automatic cordless type, magneto cordless pyramid type, and magneto cord type. Tenders will be received by the Deputy Postmaster-General, Melbourne, up to 2 p.m. on Tuesday, December 12. Local representation is essential. The Department of Overseas Trade can give to United Kingdom firms not already represented the names of firms who may be willing to act as their agents. A set of the general and special conditions of tender, together with the specification and blue prints are available for inspection by United Kingdom firms at the Department of Overseas Trade (Room 50A).

Shipbuilding in China.—The Chinese Government Bureau of Economic Information reports that the Shanghai shipbuilding companies were fully occupied throughout the year with the fulfilling of old contracts. The Kiangnan Dock and Engineering Works launched 21,496 tons and completed 18,355 i.h.p. of machinery. Two of the vessels launched were the Oriental and Cathay, 7,150 gross tons each, which were built for the account of the United States Shipping Board. They are sister ships of the Mandarin and Celestial completed in 1920. The New Engineering and Shipbuilding Works launched 15 vessels, having a total of 5,203 gross tons, and built engines and boilers for an aggregate of 5,724 i.h.p. The Shanghai Dock and Engineering Company, Limited, completed six vessels, having a deadweight capacity of 11,243 tons, and constructed engines for a total of 5,977 i.h.p. It is a significant fact, adds the Bureau, that shipowners in Chinese waters are looking more and more to local yards to supply new tonnage, and in particular vessels of shallow draught. The work done by the local yards has been pronounced by experts to be comparable in standards of quality with that done in other countries.